BAY AREA STUDY OF AVIATION REQUIREMENTS

# AIRPORT & AIRSPACE CAPACITY ANALYSIS

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MAY, 1970



THIS REPORT WAS PREPARED FOR THE BAY AREA STUDY OF AVIATION REQUIREMENTS AND THE ASSOCIATION OF BAY AREA GOVERNMENTS; THE PREPARATION OF THIS REPORT WAS FINANCED IN PART THROUGH AN URBAN PLANNING GRANT FROM THE DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT, UNDER THE PROVISIONS OF SECTION 701 OF THE HOUSING ACT OF 1954 AS AMENDED.

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# 1. OBJECTIVE AND SCOPE OF STUDY

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This study is one of several being accomplished by consultants for BASAR in their Bay Area Study of Aviation Requirements. The objective and scope of this study is succinctly stated in the contract, which is paraphrased below:

## 1.1 - Objective

To analyze the capacity of aviation facilities in the Bay Area to accommodate present and forecasted future demand for aviation service. Aviation facilities include both airports and airspace.

## 1.2 - Scope

The study area includes the counties of Alameda, Contra Costa, Marin, Napa, San Francisco, San Mateo, Santa Clara, Solano and Sonoma.

The analysis included both airline and general aviation traffic and military traffic to the extent that it affects the capacity of civil facilities.

Airport capacity has been computed for individual airports, and considers the interrelation between the airports. Further, the airport capacity evaluation includes airspace capacity to the extent that it affects the Bay Area airports.

The airports and airways system has been analyzed separately for the existing facilities, and for the planned and future additions, and air traffic control procedures appropriate to the year of analysis, have been used.

The methods used in this analysis have been documented herein, and the BASAR/ABAG staffs have been briefed during the project on the concepts and application of the procedure.

# 2. SUMMARY OF FINDINGS

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1. The existing civil airport system with the existing instrument runway selection, can operate to capacity without serious restriction from airspace conflicts, although complex air traffic control procedures are required. However, aircraft operations at the military airports, Alameda and Moffett, cause conflict with the major civil airports and can result in reduction of capacity at the major airports. Capacity forecasts have been made without assessing any penalty for operations at Alameda and Moffett Air Bases. The annual capacity of the existing system, with present aircraft types continued in operation, is summarized below:

| | |
|---|---|
| . Oakland North | - 546,000 |
| . Oakland South | - 221,000 |
| . San Francisco Int'l Airport | - 424,000 |
| . San Jose Municipal Airport | - 515,000 |
| . 32 Public Use General Aviation Airports | - 6,534,000 |
| . Total Capacity Available for General Aviation | - 7,520,000 |
| . Total Capacity Available for Air Carrier | - 720,000 |

2. The total capacity of the present system exceeds present activity, but many of the general aviation airports are distant from the population centers and, therefore, not readily usable to satisfy the demand.

3. The dominant wind circulation of the Bay Area is from the west favoring aircraft operations into that direction, with easterly flow next in frequency. Accordingly, runway orientations of the Bay airports are east-west. A small percentage of southerly winds do require complicated air traffic flow when they occur.

4. Limitation of the airspace in the Bay Area requires use of complex operational techniques by the control agencies to achieve the present day capacity. This includes coordinating the direction of runway operation at San Francisco and Oakland Airports. The present heavy concentration of air carrier operations at one airport, San Francisco, instead of at three airports, helps alleviate the complexity, but this situation will not continue into the future if air carrier traffic continues to increase at Oakland and San Jose Airports.

5. The airport system with the three major airports expanded to the indicated master plans will have serious low altitude airspace conflict due to airport interactions, and capacity will be seriously restricted. The capacity of the expanded individual airports depends on which airport is given priority in use of the airspace. Consequently, the following summary of capacity shows the three combinations of capacity, with each airport being given first priority in one case:

| | Airports With Priority | | |
|---|---|---|---|
| | San Francisco | Oakland | San Jose II |
| Oakland | 695,000 | 725,000 | 446,000 |
| San Francisco | 562,000 | 557,000 | 492,000 |
| San Jose II | 309,000 | 309,000 | 768,000 |

6. The forecasted increase of future traffic will require additional airway routes, and improved air traffic control procedures and equipment in the study area. Further growth of the primary airports will create the need for additional feeder fixes.

7. Because of the serious low altitude airspace problems involved in future airport development, the Phase II study of alternatives should include realistic assumptions for future IFR operations at military and general aviation airports. This should recognize the growth in IFR operations forecast for general aviation traffic.

# 3. ANALYSIS OF AIRSPACE USE BY THE EXISTING AIRPORT SYSTEM

***********************************

The aviation facilities of nine counties are encompassed in the study area. The counties included are:

| | |
|---|---|
| Alameda | Contra Costa |
| Marin | Napa |
| San Mateo | San Francisco |
| Santa Clara | Solano |
| Sonoma | |

These aviation facilities include the airports, as well as the airspace in which the control agencies regulate the operation of aircraft in flight.

This section presents the results of observations and analysis of the airspace, air traffic flow, and airport capacity of the existing system.

## 3.1 - Present Airspace

To determine the loading of, and operation in, the present airspace, several information sources were used. Publications and maps were assembled which contain descriptions of the airspace in the study area and the agencies responsible for the procedures and their use. Air traffic analysts (former FAA and military controllers) examined and mapped the problems of directing aircraft in flight through the area, and on approach/departure to the airports of concern. Agreement letters between the FAA control agencies were obtained, which describe the various limits of responsibility and where coordination is required to "handoff" aircraft between agencies and sectors within them. This preparation was followed with the organization of a survey team that visited the control centers and selected airport control towers.

Simultaneous on-the-scene observations at key airports are desirable. Therefore, surveys were conducted at both Oakland and San Francisco control towers and at the FAA Central Control Centers (to be described later) on the same days. The survey included observations at San Jose at a later date. Details of aircraft operations were recorded at these and many other airports in the nine counties to reflect airport operating techniques for the capacity studies to be made. Photography of the radar scopes was used to record the air activity.

These photo-records show the density and flow of aircraft in the study areas, as well as the interactions between aircraft operating into or out of the airports. Flight progress strips for the days of observation were obtained from the FAA - these are used to identify aircraft types on their routes of flight.

Visits were also made with the FAA personnel responsible for directing control at the airports and in the airspace. This established a dialogue for determining present problems, corrective measures being proposed and future plans.

3.1.1 - General Description of Air Traffic

The enroute and terminal airspace systems for navigation and control of Instrument Flight Rules (IFR) air traffic, over the nine county BASAR area of Northern California, reflects the geographical position of the San Francisco Bay Area as a major western air terminal of Continental United States air routes and as an aerial gateway to the Far East. In addition to the long range air traffic terminating from Continental and Oceanic air routes, the BASAR area supports a heavy volume of intra-state air traffic operating between its contiguous civil air carrier and general aviation airports and those located in Southern California.

Military air activities located within the BASAR air traffic control complex, share airspace with civil air traffic when operating out of Alameda and Moffett Naval Air Stations. Military aircraft operating out of Hamilton and Travis Air Force Bases also utilize the enroute airway system serving the Bay Area. However, except for a limited amount of special traffic using civil air terminals, Hamilton and Travis aircraft are generally routed outside of the terminal traffic patterns of BASAR civil air carrier and general aviation airports.

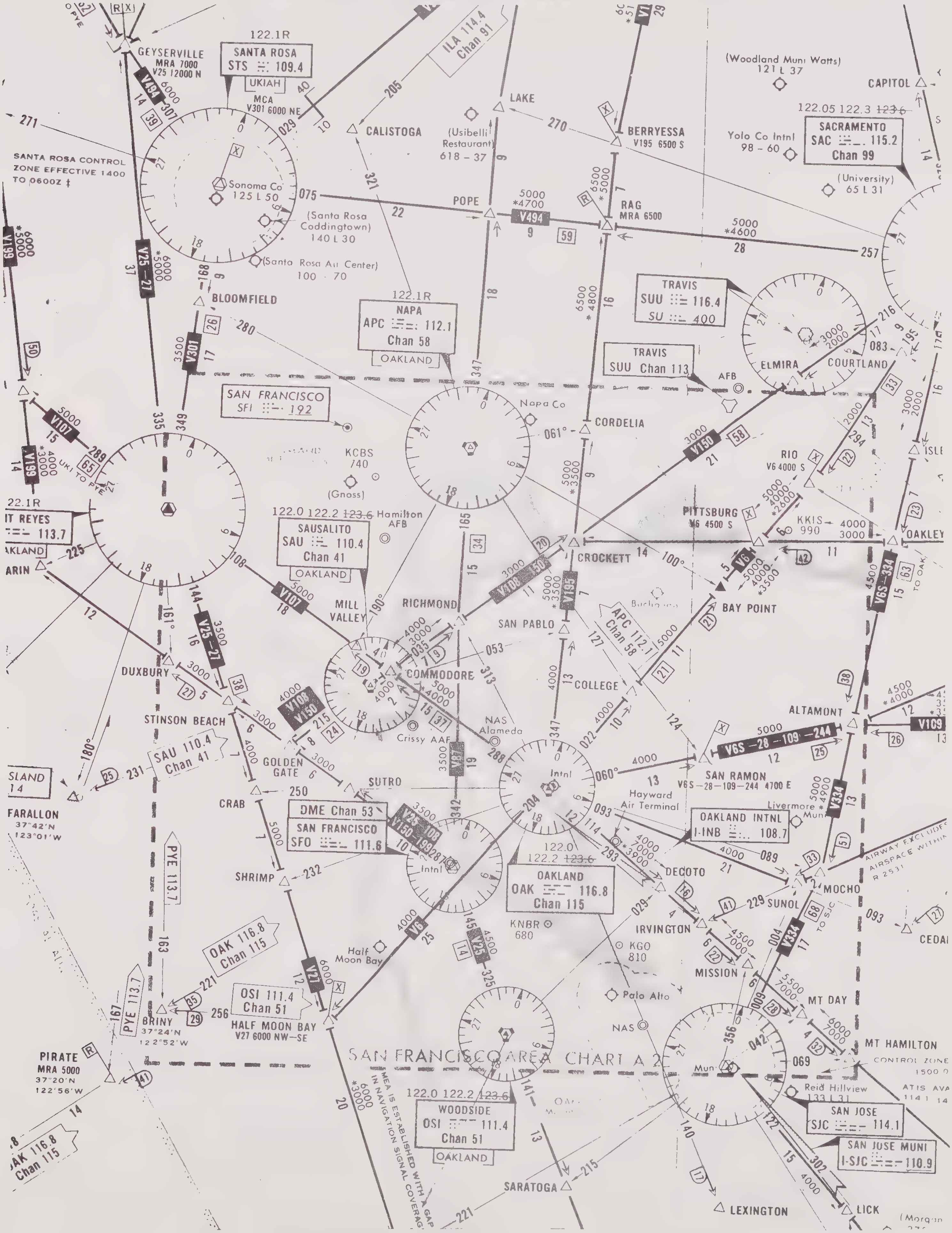
Figure 3-1, extracted from a current U.S. Government Enroute Low Altitude Flight Information publication, illustrates the enroute and terminal navigational aid structure supporting air operations in the BASAR area.

3.1.2 - BASAR Air Traffic Control Agencies

Responsibility for control of IFR air traffic in the BASAR area is assigned to the Oakland Air Route

FIGURE 3-1

# LOW ALTITUDE ENROUTE MAP



Traffic Control Center (ARTCC). In accordance with current FAA procedures, specific portions of this airspace are delegated to terminal or approach control agencies. These are the Oakland Terminal Radar Control (TRACON), and the Hamilton and Travis Radar Approach Control Centers (RAPCON).

The Oakland TRACON facility is the major instrument approach control agency in the BASAR area. It provides arrival and departure service to San Francisco, Oakland, San Jose, Alameda and Moffett. As shown in Figure 3-2, airspace delegated to the Oakland TRACON covers approximately 60 percent of the nine county BASAR area.

Two military air traffic control agencies, i.e. Hamilton and Travis RAPCON's provide air traffic control terminal service to their respective air bases, and to general aviation airports at Napa and Concord. Both Hamilton and Travis RAPCON's interface with the Oakland TRACON to provide low altitude "Tower Enroute Service" to airports within the BASAR area, as well as to adjoining counties.

Only aircraft operating in accordance with IFR procedures are controlled by the above control agencies. These represent approximately 15 percent of all the air traffic in the study area. In 1968 it is estimated that there were 3,834,000 landings and takeoffs at public use airports in the BASAR area.

Visual Flight Rules (VFR) traffic is largely uncontrolled, but becomes subject to control at airports with control towers. The airports with control towers in the BASAR area are:

| | |
|---|---|
| Oakland | San Francisco |
| San Jose | Buchanan |
| Hayward | Napa |
| Palo Alto | Reid-Hillview |
| San Carlos | Sonoma |

### 3.1.3 - Existing Airspace Traffic Flow

Standard Instrument Departure (SID's) routes and Standard Arrival Routes (STAR's) are published to organize traffic flow. In the study area, because of the concentration of airports in the vicinity of San Francisco Bay, a complex series of SID's and STAR's have been devised. These are shown for the main airports in Figures 3-3 and 3-4.

FIGURE 3-2

# BASAR TERMINAL AIR TRAFFIC CONTROL AGENCIES

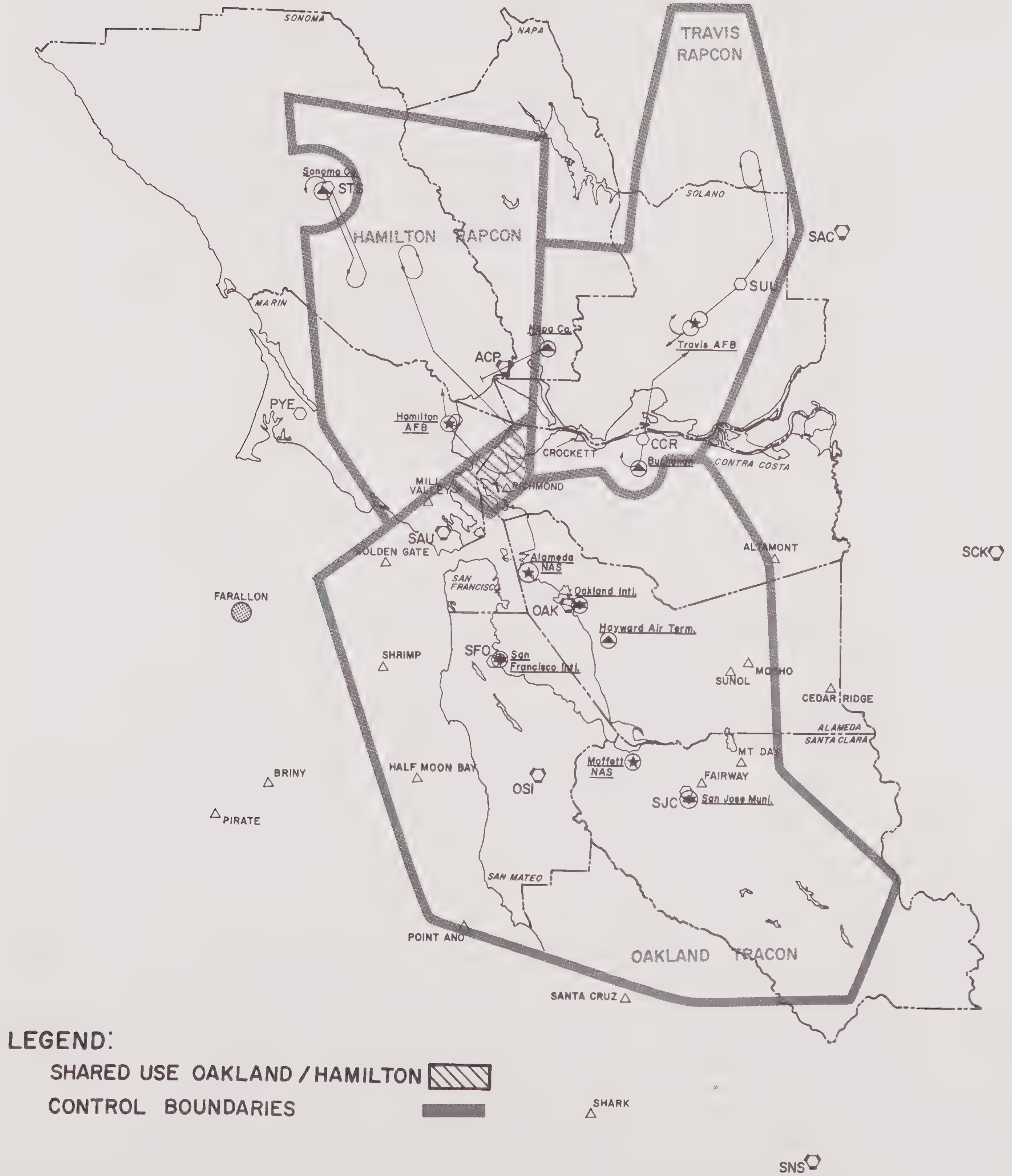


FIGURE 3-3

# OAKLAND TRACON PROCEDURES
# WEST PLAN

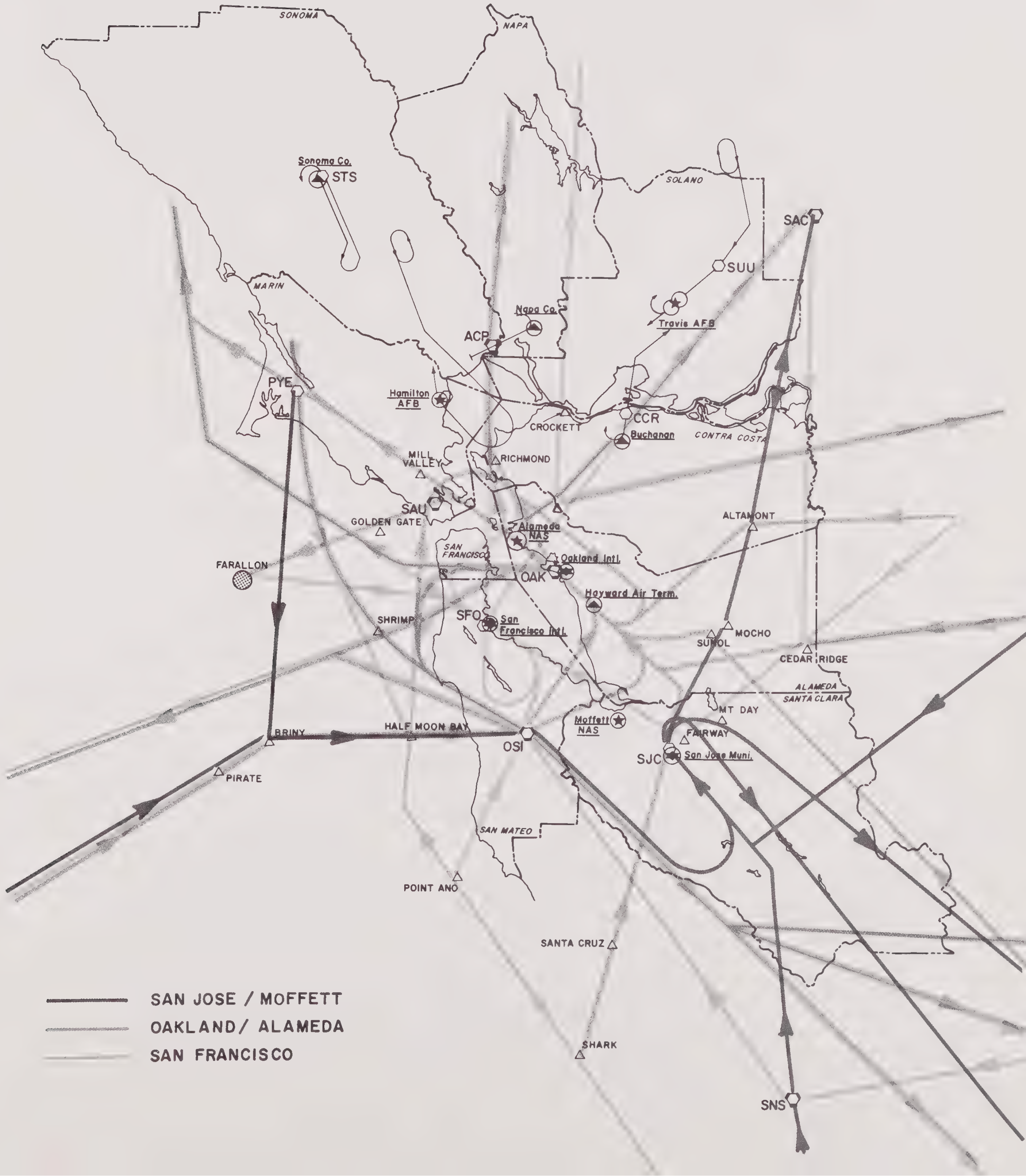
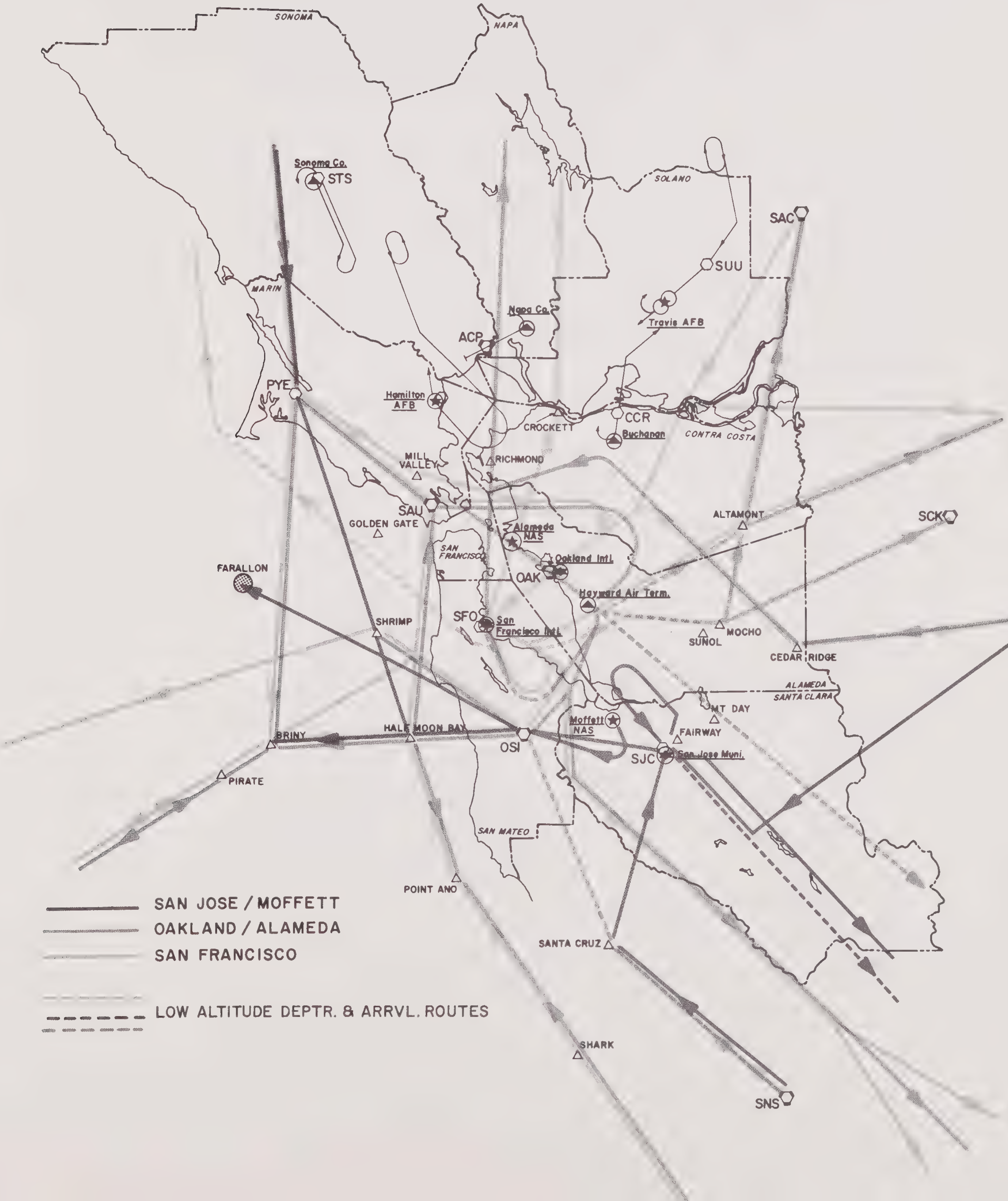


FIGURE. 3-4

# OAKLAND TRACON PROCEDURES SOUTHEAST PLAN



These routes can be followed or flown by reference to a common system of ground based navigational aids. The development of these procedures is complicated by the restrictions to the use of low altitude routes, and holding patterns, caused by either mountainous terrain features, noise abatement procedures, and/or proximity to other airports.

In order for the Bay Area air traffic control system to work and handle the volume of air traffic currently transiting the area, positive radar control service is provided by the Oakland (ARTCC) Center, in close coordination with the TRACON and two RAPCON's described above. Aircraft are expedited to the final approach course, or to an outbound routing, from each Bay Area airport by the appropriate radar control facility. Altitude restrictions are applied where necessary to ensure sufficient in-flight separation and, in the case of departures, to facilitate tunneling of departure traffic through the arrival flow.

The analysis of the traffic flow within the Bay Area is aided by the photographic records (16 mm movie) of the TRACON radar. The movie record of air traffic as depicted on the radar display, is projected for study at a speed that displays an eight hour period of operations in less than ten minutes. Figures 3-5, 3-6 and 3-7 are tracings of actual traffic flow during VFR conditions on August 13, 1969, as derived from radar photography. All aircraft in flight over most of the study area are depicted by the traces. Figure 3-8 is the total one-and-one-half hour period, but only for the traffic from the three major airports. West Plan procedures were in effect. On Figure 3-5 note the blurred area just left of center where a flight of aircraft arrived at Alameda NAS from a mission and made a few practice landings. Figures 3-6 and 3-7 show clearly the runway use airspace relationships between each airport. The traffic flow also shows the extensive coordination achieved to handle the crossing traffic flows.

A large number of non-transponder radar targets were observed throughout the entire terminal area, and can only be partially depicted in Figures 3-5, 3-6 and 3-7, because of their short duration on the scope.

# OAKLAND TRACON RADAR TRAFFIC
## 4:30-5:00 P

FIGURE 3-6



# OAKLAND TRACON RADAR TRAFFIC
## 5:00-5:30 P

FIGURE 3-7

# OAKLAND TRACON RADAR TRAFFIC
## 5:30-6:00 P

FIGURE 3-8

# OAKLAND TRACON RADAR TRAFFIC
## 4:30-6:00 P

In an area southeast of Hayward (in the vicinity of the Decoto intersection), numerous targets were observed flying a racetrack pattern. Aircraft operations of this type on the extended centerline of a major civil air terminal can result in excessive controller workload in issuance of traffic advisories required by current radar traffic control procedures. This information may be useful in the design of approach/departure routes.

The radar photography was performed just prior to a change in departure and arrival route procedures (SID's and STAR's). A comparison of the photographic records with the routings of the new SID's and STAR's, showed these routings to be only slightly different from those in effect at the time of the surveys.

### 3.1.4 - IFR Airport Airspace Reservations

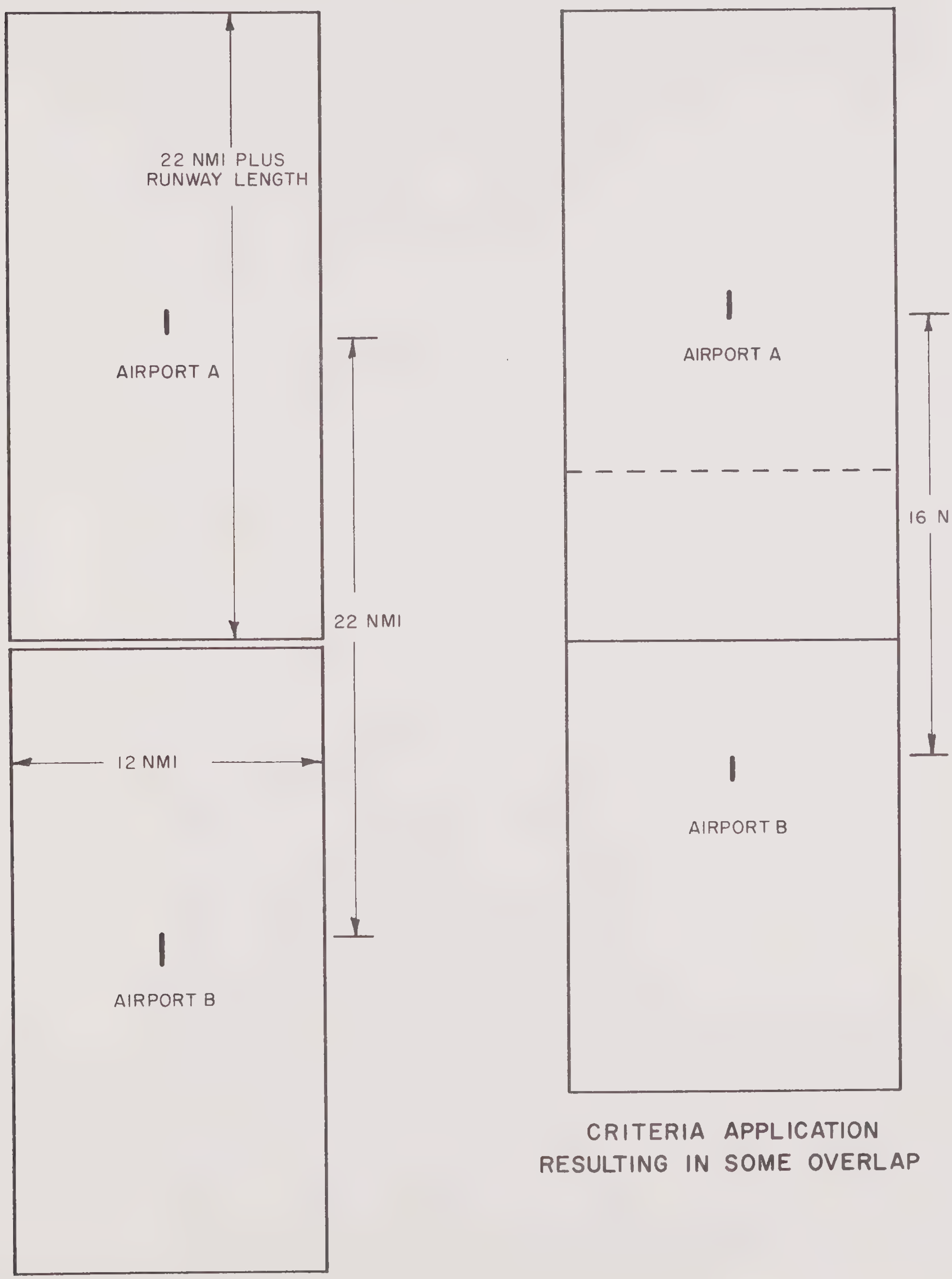
It has been found helpful in airspace planning to show blocks of airspace around an airport which should be kept free of all other traffic - an airspace reservation. The reservation is made large enough to permit approach and departure paths to be accomplished without restriction from other airports. This reservation can be plotted for each airport in the airport system to see potential airspace conflict.

The reserved area dimensions are a function of both the mission of the airport and the characteristics of the aircraft using it. The dimensions are extensive at an air carrier airport with several long runways oriented in parallel to each other. Figure 3-9 indicates the dimension desirable for a single runway air carrier airport as determined by Speas Associates. The length and width are both increased with multiple parallel runways. FAA Order 7480.1 dated February 9, 1966, establishes similar criteria.

The airspace reservation area on one end, has a dimension in length adequate for vectoring an aircraft onto final approach and for descent down the ILS glide path. The distance needed for the aircraft taking off is added to the opposite end of the runway with sufficient length to protect the climb out and turn path. On either side parallel to this total length, sufficient lateral space is reserved for an aircraft to turn back and still have lateral separation from other aircraft.

FIGURE 3-9

# SCHEMATIC OF AIRSPACE RESERVATION CRITERIA




IDEAL CRITERIA APPLICATION

CRITERIA APPLICATION RESULTING IN SOME OVERLAP

Two major airports are shown in the schematic of Figure 3-9, located to show an ideal application and an "overlap" situation. Initially, the dimensions described are applied in a "no trespass" fashion. Some overlap may be possible, provided that the same direction of runway operation can be assured at both airports. This is because the length needed for take-off is less than the distance needed for landing. A minimum distance is needed that permits the departure to climb and turn before entering the airspace reserved for arrivals.

General aviation IFR airports use an airspace reservation criteria of smaller dimensions in keeping with the maneuvering capability of smaller aircraft. The approach/departure distance for a single instrument runway is six miles, plus the runway length, while the lateral dimension is the same as for air carrier airports.

General aviation VFR airports should not be located within the IFR airspace reservation areas described above. The aforementioned FAA Order 7280.1 suggests a VFR traffic pattern airspace need on the order of two by five miles.

Use of Criteria

The patterns depicted in Figure 3-9 can be constructed on appropriate land use maps or navigation charts for each airport in the system. Similar patterns can be constructed for any proposed new IFR airport site to be evaluated. Ideally, no patterns should overlap. Overlapping patterns can result in inter-airport conflict reducing capacity at one or both airports or increasing controller workload.

### 3.1.5 - BASAR Airport Airspace Reservations

Application of the airspace reservation criteria to the BASAR areas, is shown in Figure 3-10. In the northerly part of the BASAR area adequate airspace is available for operation of Sonoma County, Napa County, and Buchanan Field as general aviation IFR airports, providing that Hamilton and Travis Air Force Bases retain their present runway configurations. Use of either Napa County or Buchanan Airports for limited air carrier operations, is possible with the development

FIGURE 3-10

# AIRSPACE RESERVATION CRITERIA APPLIED TO BASAR AIRPORTS

of complex air traffic control procedures. Sonoma County Airport is sufficiently remote to allow for expansion of its activities.

Figure 3-10 also illustrates that much conflict between airspace reservations occurs in the southern counties of the BASAR area. The overlapping airspace reservations of the present airports, shown by application of the criteria, are reflected by the complex air traffic control procedures developed for the Bay Area. This crowded airspace situation has been examined by detailed layout and review of approach and departure paths.

By study of the SID's and STAR's presented earlier, and their expansion to capacity operation of the present airports with their aircraft mix, it is concluded that airspace conflicts will not materially affect the capacity of the major airports. However, when additional runways are added to the major airports, as envisioned on the airport master plans, serious airspace conflict results. This is treated in a later section.

# 4. THE CAPACITY OF THE EXISTING AIRPORT SYSTEM

**************************************************

Analysis of airport operations and capacity proceeded in parallel with the airspace study. The BASAR Project Director provided plans for the existing major airports and, with his agreement, the list of general aviation airports to be considered in this study was developed. FAA Forms 29A provided preliminary descriptions of the general aviation airports, the location by the nearest town, the geographical coordinates and pertinent operating information useful to the capacity analysis.

Visits were made to the busier airports to gather data. Following the detailed data gathering at Oakland, San Francisco and San Jose, described earlier, visits were made to Buchanan Field, Hayward Air Terminal, Livermore Municipal, Napa County, Palo Alto, Reid-Hillview, San Carlos and Sonoma County.

## 4.1 - The Present Airport System

The location of airports in the BASAR study area are shown in Figure 4-1. The backbone of the area air transportation system is the three major air carrier terminals - San Francisco International, Oakland International, and San Jose Municipal. These airports, by the very nature of their operations, have long runways with sufficient pavement strength to be able to handle large jets; extensive taxiway systems to prevent delays; complete lighting and navigational aids to enable the airport to maintain operations around the clock; and large terminal facilities. The major airports all have general aviation operations to some extent, with San Francisco having some 35 percent, Oakland some 85 percent, and San Jose approaching 80 percent.

As the air carrier traffic at these major airports increases, the amount of general aviation traffic tends to decrease. A network of general aviation airports has grown to accommodate the heavy volume of general aviation aircraft. Located throughout the nine county Bay Area, in addition to the three major airports, are 46 general aviation airports. Several of these also serve as alternate landing fields and reliever fields for the air carrier airports. Of these 46, 32 are classified as public use (open to itinerant flights), and 14 as private (not available to the public except in an emergency). Figure 4-2 lists the public use airports including the three major airports.

A major portion of the operations (on the order of 60 percent) at these general aviation airports consists of touch-and-go's for training. In this maneuver, the pilot enters the approach pattern and heads to the runway as if to land; however, as soon

FIGURE 4-1

# AIRPORTS IN THE BASAR AREA PUBLIC USE AND MILITARY

Figure 4-2

EXISTING PUBLIC USE AIRPORTS

Alameda County

- Livermore
- Hayward
- Fremont
- Sky Sailing
- Oakland

Contra Costa County

- Antioch
- Buchanan

Marin County

- Gnoss Field
- Smith Ranch

Napa County

- Angwin
- Calistoga
- Napa County
- Usibelli Restaurant

San Francisco

- None

San Mateo County

- Half Moon Bay
- San Carlos
- San Francisco

Santa Clara County

- Palo Alto
- San Jose
- Reid-Hillview
- Morgan Hill

Solano County

- Nut Tree
- Rio Vista
- Vaca-Dixon
- Vacaville
- Maine Prairie
- Tremont

Sonoma County

- Sonoma County
- Cloverdale
- Healdsburg
- Petaluma Sky Ranch
- Santa Rosa Air Center
- Santa Rosa Coddingtown
- Sonoma Valley
- Sonoma Sky Park
- Sea Ranch

as his wheels touch, he accelerates and takes off again. Such operations occur at most general aviation airports.

There are also five military bases in the Bay Area. They are equipped similar to air carrier airports in terms of facilities and equipment. They have been considered only as they interact in the airspace situation. The military count at these bases is as follows:

| | | | | | |
|---|---|---|---|---|---|
| Moffett | - | 113,841 | Alameda | - | 136,504 |
| Travis | - | 121,134 | Crissy | - | 4,975 |
| Hamilton | - | 58,476 | | | |

## 4.2 - Methodology for Airport Capacity and Delay Computation

Over a period of years, techniques for computing the capacity of an airport have been developed by the consultant. Mathematical models have been developed which accurately represent runway operations by relating movement rate to average delay. These mathematical models are incorporated into computer programs for computing practical hourly capacity, practical annual capacity and annual delay. The computer programs are described in the Appendices. Here is presented a brief introduction to the techniques.

### 4.2.1 - Practical Hourly Capacity (PHOCAP)

PHOCAP is defined as that movement rate (takeoff and landing rate) which results in a tolerable average delay level to the aircraft. From work in this area over a period of years, it has been concluded that at major airports, PHOCAP is reached when the average delay is four minutes. For smaller general aviation airports an average delay of two minutes is used. The delay levels have been picked for several reasons; 1) the variation of delay around the average (typically for a four minute average, one can expect delay to vary from zero to 18 minutes); 2) the operating costs of aircraft when experiencing delays; and 3) keeping the number of aircraft waiting in a queue (whether they are on the ground, or in the air) to a reasonable level. The delay computed is that due to runway operations and limitations of approach/departure airspace.

The PHOCAP computation includes evaluation of the following variables in airport design and operation which must be specified for the airport.

- Runway length, turnoff locations, and turnoff types (i.e. right angle, high speed).

- Aircraft operational variables classified into five classes of aircraft (shown below).
- Weather in terms of VFR or IFR.
- Time period of the analysis (present, or post-1975 period).
- Instrument approach path variations.
- Instrument departure paths available.
- Operating rule restrictions in effect (noise abatement, preferential runway use).

The population of aircraft operating at an airport is described in five classes as follows:

| Class | Typical Aircraft | |
|---|---|---|
| A | Large Jets: | 707;720;Convair 990;880;DC-8; VC-10. |
| B | Smaller Jets: | Large Turbo Props and Piston Transports; 727,737,DC-6/7/9; BAC.111; Lockheed Electra; Constellation; Vanguard. |
| C | Heavy Twins: | F27; Lear Jet; Jet Commander; Beech 18, 99; Grumman Gulfstream I/II; Twin Otter |
| D | Light Twins/ High Performance Single: | Aero Commander; Apache; Queen Air; Cessna 310; Bonanza. |
| E | Light Singles: | Cessna Series 150-210; Mooney 20 Series; All Cherokees. |

The above listing of aircraft does not indicate the wide body jets - the 747, the DC-10, and the L.1011. For purposes of the capacities presented herein, they have been assumed to be Class A - Large Jets. However, future capacity evaluations should preferably place the wide body jets into a "Heavy Jet" class because of recent regulatory action by the FAA. On February 27, 1970, the FAA issued new separation criteria to be applied in conjunction with Heavy Jet class. Briefly, the regulation increases the separation of any aircraft

whose certificated weight is less than 300,000 pounds, when such aircraft follows a heavy jet - one with certificated weight of 300,000 pounds or more. This regulation will reduce capacity at airports where the heavy jets operate.

The consultant's PHOCAP computer program (Appendix A) is being revised to reflect the new separation criteria. This effect cannot be included in the current report, but an indication of the extent of the capacity reduction has been determined by a manual computation of a typical case. For an airport with 20 percent heavy jets, the indicated capacity reduction was about ten percent for arrivals, 20 percent for departures, and ten percent for mixed operations on the same runway.

### 4.2.2 - Practical Annual Capacity (PANCAP)

Whereas the airport planner or operator needs to know the hourly capacity of his airport, he is usually more concerned with the amount of traffic his airport can handle annually at a reasonable delay level. Therefore, a technique has been developed by the consultant (Appendix B) to compute an annual capacity. This capacity is selected at a delay level to assure reasonable service to the public. Thus, some peak hour movement rates are permitted to exceed the four minute average delay level, but this is controlled to assure the proper service level.

The technique to compute PANCAP has been incorporated into a computer program which, in effect, simulates airport operations and computes the delay to operations during the heavily loaded hours of the day for all of the airport's operations over a year's time. The simulation compares airport capacity for each hour of the year to the forecast demand for each hour of the year. The hours of the year when the demand exceeds practical capacity are recorded, and the resulting delay is computed, as well as the number of operations occurring during those hours. When the number of overload hours, the delay during those hours, and the operations occurring during those hours, reach certain levels, the total operations thus achieved are then called Practical Annual Capacity (PANCAP).

The PANCAP computation results are described as an annual rate such as 400,000 operations. A useful

additional characteristic of this annual number is that the average peak hour on the peak days of the year is determined. For example, for the 400,000 operations, the average peak hour on the peak days would typically be about 90 movements per hour. This is a useful number for the planning of other facilities such as gates, parking, fueling and similar items.

### 4.2.3 - Annual Delay (ANDE)

A useful extension of the PANCAP program is one which computes the annual delay to operations for one year. This program (Appendix C) sums all of the delays incurred by aircraft for each hour of the year, including those at less than capacity operations,(that is, less than four minutes average delay).

ANDE is extremely useful in calculating a cost/benefit ratio for airport runway improvements. From airline data aircraft operating costs per hour have been evaluated. With this data, the annual delay in hours can be converted into monetary value. If the annual cost reduction is greater than the annual cost of the airport improvement, then a favorable cost/benefit ratio results.

## 4.3 - Capacity Assumptions and Constraints

San Francisco, Oakland, and San Jose Airports were analyzed in depth because they are of major interest. However, a number of basic assumptions were necessary concerning general aviation airport operations. These were as follows:

- At uncontrolled general aviation airports, even if there is more than one runway, only one runway at a time is used in accordance with the prevailing winds.

- The crosswind criteria at all fields is assumed to be 15 knots.

- Types of aircraft were estimated at each facility according to its runway length, types of service offered by the airport, FAA Form 29A and, when possible, personal observation. Traffic was observed first-hand at the major airports and at Livermore Municipal, Hayward Air Terminal, Buchanan Field, San Carlos, Palo Alto, Reid-Hillview, Sonoma County and Napa County.

- IFR traffic will exist only at fields with approved approach procedures.

- Unpaved runways have less capacity than an equivalent paved runway. This is because on landing, an aircraft occupies the runway longer, and acceleration time for takeoff is increased. A reduction factor of 0.9 has been applied (based on aircraft performance curves) to adjust for this situation.

- Individual airfield capacities have been adjusted suitably in special cases for:

  Special operating conditions
  Airspace restrictions
  Lighting equipment for night operations

- Touch-and-go figures have been included in capacities unless specifically not warranted.

It must be remembered that general aviation airports are subject to significant changes. Thus computed capacities for an airport with a single sod runway today, may be much different in 10 or 20 years, after the possible installation of a pair of paved, longer, intersecting, lighted runways. In addition, the nature of the aircraft patronizing the field would change. Therefore, in the following text the basis for capacity computation is stated for each airport.

## 4.4 - Bay Area Meteorology

The topography of the Bay Area is comprised of nearly parallel ranges of low mountains with intervening valleys of various widths. Most of the ranges are between 2,000 and 4,000 feet high.

North of San Francisco, uniformity of altitude is prominent, and no broad summits remain. There are four parallel ranges in this region. Named in order from east to west, these ranges are the Yolo, Napa, Sonoma, and Marin. The intervening longitudinal valleys named in the same order are the Berryessa, Napa, and Petaluma.

South of San Francisco there are some broader rolling uplands, but interspersed among these are higher crests and the general aspect is less plateau-like than it is farther north.

Weather conditions throughout the Bay Area are generally homogeneous and fairly uniform. From early Spring to late Fall the weather consists of occasional periods of low stratus clouds, bases 300 feet to 1,200 feet, forming in the early afternoon or evening and dissipating by the early forenoon.

During the winter months, so called "storm" conditions occur. The resulting weather pattern brings moderate to heavy showers to the area on strong southerly winds with accompanying turbulence, which is occasionally moderate or heavy.

In the early spring months, as the winter storms diminish, periods of fog occur. These conditions are not considered to be a major factor in the Bay Area weather. On the average, fogs usually lift or dissipate by mid-day and do not close the airports to flight operations on more than a few days per year.

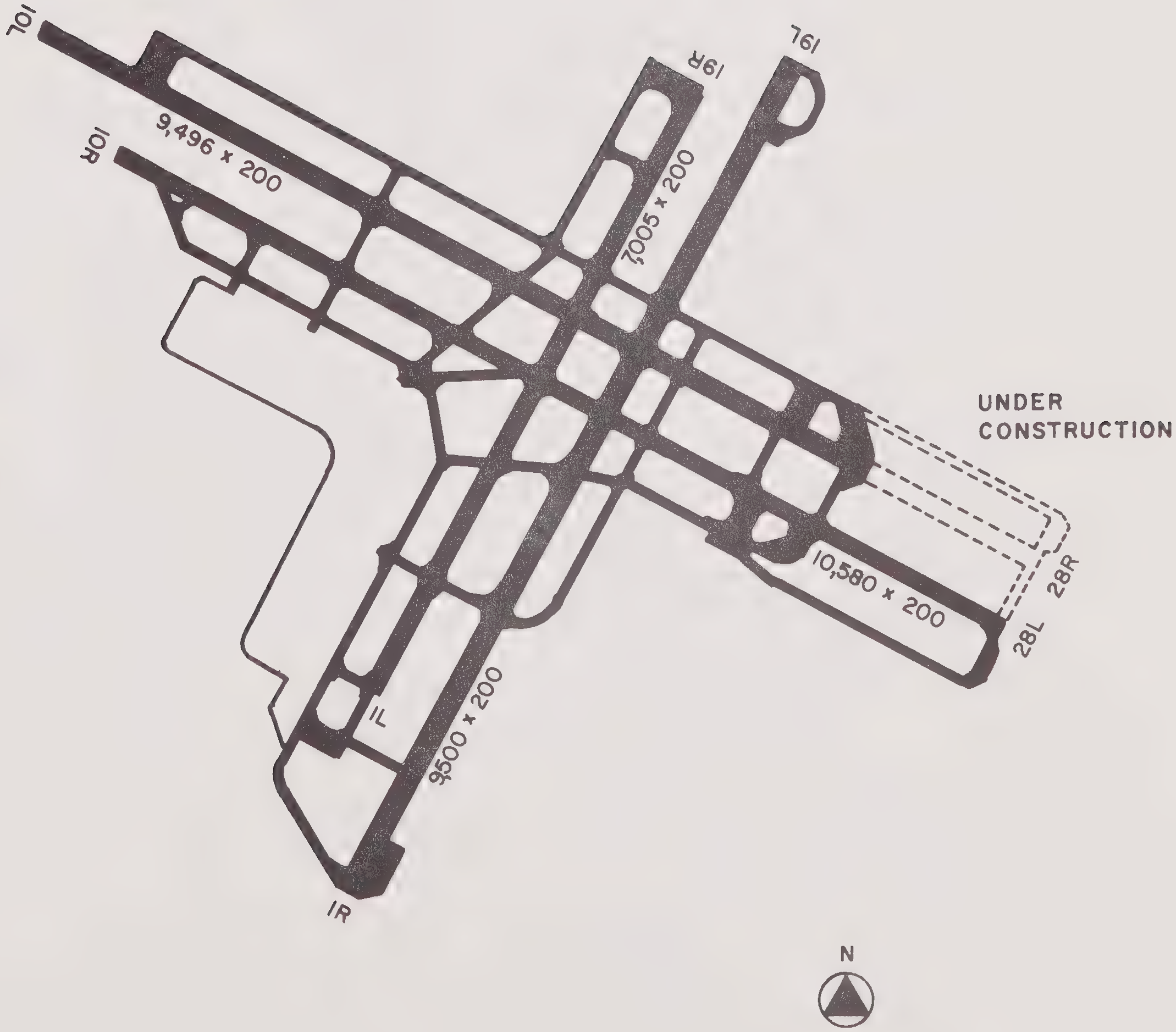
Weather records for Bay Area stations were obtained from the National Weather Records Center of the Environmental Services Administration, Asheville, North Carolina and subjected to computer analysis. These provided windrose data for various ceiling/visibility categories. While the analysis was made specifically for Oakland, San Francisco, and San Jose, it was determined through discussions with the Weather Bureau Forecast Center at San Francisco and the Air Force Climatologist at Moffett NAS, that they could be applied fairly uniformly to to the airports in the remainder of the study area. In general, occurrence of visual flight rule (VFR) weather is 90 percent and the occurrence of instrument flight rule (IFR) weather is 10 percent. Precise weather data was used for Oakland, San Francisco, and San Jose while extensions of these data were applied to the general aviation airports.

## 4.5 - Capacity Analysis of San Francisco International Airport

The runway layout for the airport is shown in Figure 4-3. It is located on the west shore of San Francisco Bay, 12 miles south of the San Francisco Civic Center. The immediate vicinity is flat as the airport has been built to a large extent on filled tideland. The Bay borders the airport from north to southeast. San Bruno Mountain, five miles distant from the airport north to northwest, rises to 1,300 feet. A range of coastal hills, with elevations 700 to 1,900 feet, extends from northwest to south. The north-south ridge of this range is four miles west of the airport at an elevation of 1,300 feet. The Pacific Ocean beyond this ridge is six miles from the airport. A broad gap to the northwest between San Bruno Mountain and the coastal hills, has a minimum elevation of 150 feet. This gap permits a considerable flow of maritime air, which passes directly over the airport much of the time, especially during the summer. This feature exercises a dominant control over the local climate.

FIGURE 4-3

# SAN FRANCISCO INTERNATIONAL AIRPORT



The aircraft population during VFR weather at San Francisco Airport was determined from analyzing airport operations. An IFR population was derived based on the deletion of aircraft types from the population which do not normally operate in IFR weather. These populations are:

| | Percent | |
|---|---|---|
| Class | VFR | IFR |
| A | 38 | 47 |
| B | 24 | 37 |
| C | 7 | 7 |
| D | 18 | 7 |
| E | 13 | 2 |

A large proportion of the lighter aircraft (Classes D and E) are engaged in air carrier commuter operations.

Hourly traffic counts were used to develop the hourly demand levels used in the PANCAP computation. It is noted that these hourly levels are unusual in the high demand that applies for about twelve consecutive hours. Among the several large air carrier airports studied in the past, none have an unconstrained (that is, not limited by capacity) continuous high demand approaching the San Francisco situation. To illustrate, note the tabulated hourly demand levels below, which sum to 16.16. This indicates that in twenty-four hours San Francisco Airport handles the equivalent traffic that would occur in 16.16 peak hours. By contrast, other large airports will handle the equivalent of around 13 peak hours of traffic. This will result in a higher PANCAP for San Francisco than would result with the more normal hourly distribution.

HOURLY DEMAND LEVELS

| Hour | Ratio To Peak Hour | Hour | Ratio To Peak Hour |
|---|---|---|---|
| 0-2 | .23 | 12-14 | .98 |
| 2-4 | .13 | 14-16 | 1.00 (Peak Hour) |
| 4-6 | .14 | 16-18 | .95 |
| 6-8 | .50 | 18-20 | .88 |
| 8-10 | .98 | 20-22 | .79 |
| 10-12 | .89 | 22-24 | .61 |

Sum = 8.08

For 24 hours the sum = 2 x 8.08 = 16.16

FAA Forms 7230-1 (Daily Traffic Counts) were analyzed to develop the variation in daily demand over a one year period, as this is needed in the PANCAP analysis. The demand for the year is assigned into nine demand levels as indicated below. The peak days are assigned the ratio of 1.0 and the other eight levels their proportionate ratio. As an example of interpretation, the table below indicates that there will be a .0739 occurrence of days which are peak days (ratio = 1.0), or .0739 by 365 = 26 days per year, which are peak days.

DAILY DEMAND LEVELS

| Ratio To Peak Day | Occurrence | Ratio To Peak Day | Occurrence |
|---|---|---|---|
| 1.00 | .0739 | .76 | .0713 |
| .93 | .1425 | .83 | .0739 |
| .85 | .0356 | .77 | .1425 |
| .89 | .1398 | .70 | .0356 |
| .83 | .2849 | 7.56 | 1.0000 |

An analysis of weather bureau records is included in Figure 4-4 which is the basis for determining runway use and percent of weather requiring IFR procedures.

### 4.5.1 - Airport Operation

San Francisco International Airport consists of two sets of close parallel runways with lateral spacing between parallels of 750 feet. Noise abatement, terrain considerations, and traffic at the other Bay airports influence the runway use combinations. The high percentage use of intersecting runways (Figure 4-5) minimizes noise abatement effects and yet provides good capacity. This is aided materially by the use of runway 28R-28L for VFR landings and intersection takeoffs for light aircraft which may be on the order of 30 percent of the population. These light aircraft are largely air carrier commuter operations. The pilots through familiarity with the airport, cooperate by landing long on runway 28R (thus clearing the intersection with runway 01 in minimum time) and also make intersection takeoffs.

The use of intersecting runways overcomes another problem resulting from wake turbulence effects. In February, 1970, the Federal Aviation Administration issued a regulation requiring a three minute separation between light aircraft using intersection takeoffs and

Figure 4-4

WIND/WEATHER ANALYSIS SAN FRANCISCO
15 KNOT CROSSWIND
(IN PERCENT)

| | Runway 10-28 as Primary Direction | | | |
|---|---|---|---|---|
| | 10R&L/28R&L | 01R&L/19R&L | Not Covered | Total |
| To 700/2 | 4.35 | .04 | .01 | 4.40 |
| 700/2 - 1000/3 | 5.40 | .09 | .03 | 5.52 |
| Over 1000/3 | 87.85 | 1.71 | .52 | 90.08 |
| | 97.60 | 1.84 | .56 | 100.00 |

| | Runway 01-19 as Primary Direction | | | |
|---|---|---|---|---|
| | 01R&L/19R&L | 10R&L/28R&L | Not Covered | Total |
| To 700/2 | 4.15 | .24 | .01 | 4.40 |
| 700/2 - 1000/3 | 5.14 | .35 | .03 | 5.52 |
| Over 1000/3 | 75.75 | 13.81 | .52 | 90.08 |
| | 85.04 | 14.40 | .56 | 100.00 |

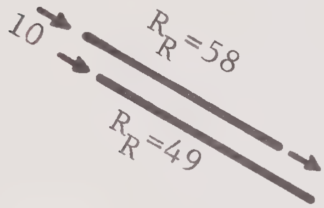
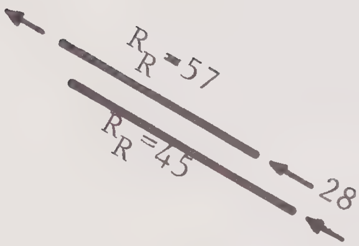
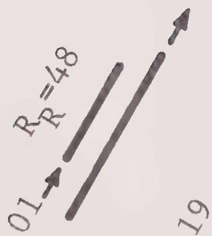
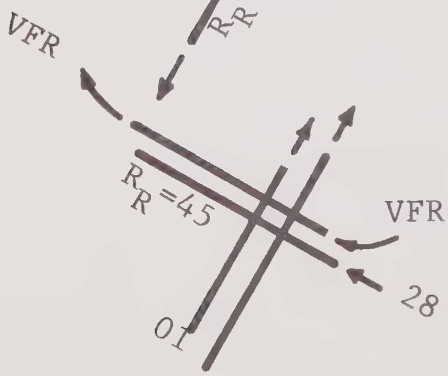
| | Single Direction Use* | | | |
|---|---|---|---|---|
| | 01R&L | 19R&L | 10R&L | 28R&L |
| To 700/2 | 3.22 | 2.71 | 2.41 | 3.72 |
| 700/2 - 1000/3 | 4.10 | 2.50 | 2.16 | 4.70 |
| Over 1000/3 | 54.42 | 41.74 | 33.68 | 74.64 |
| | 61.74 | 46.95 | 38.25 | 83.06 |

| | Runway Use as Determined for Capacity Analysis | | | | | |
|---|---|---|---|---|---|---|
| | 28R&L/01R&L | 28R&L | 10R&L | 19R&L | 01R&L | Total |
| To 700/2 | 2.3 | 1.4 | .6 | .1 | - | 4.4 |
| Over 700/2 | 37.6 | 42.3 | 13.9 | 1.4 | .4 | 95.6 |
| | 39.9 | 43.7 | 14.5 | 1.5 | .4 | 100.0 |

* A tailwind of five knots and below, is included in these percentages.

Figure 4-5

# RUNWAY CAPACITY
# SAN FRANCISCO INTERNATIONAL AIRPORT

| Runway Configurations | PHOCAP VFR | PHOCAP IFR | Percent Use VFR | Percent Use IFR |
|---|---|---|---|---|
|   | 76 | 56 | 13.9 | .6 |
|   | 78 | 58 | 42.3 | 1.4 |
|   | 70 | - | .4 | - |
|   | 70 | 52 | 1.4 | .1 |
|   | 76 | 51 | 37.6 | 2.3 |
| | | | 95.6 | 4.4 |

$R_R$ = Runway Rating (VFR)

heavy jet aircraft. With parallel runways in operation, as the 28L and 28R runways, the light aircraft must be separated in accordance with the above regulation, thus increasing spacing. With intersecting runway use, the light aircraft takeoffs are separated from the jet traffic so the intersection rule does not apply and more efficient spacing can be used.

### 4.5.2 - Airport Capacity

Figure 4-6 indicates the runway use combinations and the hourly capacity. Tower records indicate that departures exceed arrivals in the morning peak, and arrivals exceed departures in the afternoon peak. Fortunately, the multiple runway combinations in use are relatively insensitive to imbalanced arrival or departure situations so a ratio of unity has been used for the ratio of arrivals to departures.

| Demand* | Annual** Capacity | Peak Hour At PANCAP |
|---|---|---|
| 370,485 | 424,000 | 86 |

* 12 month total, April 1969 - March 1970 (with helicopter traffic excluded).

** It is noted that the Federal Aviation Administration has recently presented listings of airport capacity including somewhat different numbers than those above. It is understood the FAA numbers are for a more idealized airport and traffic situation than the current situation represented by the above capacity.

## 4.6 - Capacity Analysis of the Metropolitan Oakland Int'l Airport

A schematic of the present runway layout is shown in Figure 4-7. The airport is on the northeast shore of the San Francisco Bay on filled tidelands about seven airline miles from the center of Oakland. The coastal mountain range running in a northwest-southeast direction, separates the Bay from the Pacific Ocean on the west and from the inland valleys on the east. This range has an average elevation between 1,500 and 2,000 feet with a few peaks as high as 3,500 feet.

During VFR conditions, there is a high degree of independence between air carrier operations (the bulk of which occurs on runways 29 and 11, located on the south side of the airport), and general aviation operations (which mainly occur on parallel

FIGURE 4-6

# OAKLAND INTERNATIONAL AIRPORT

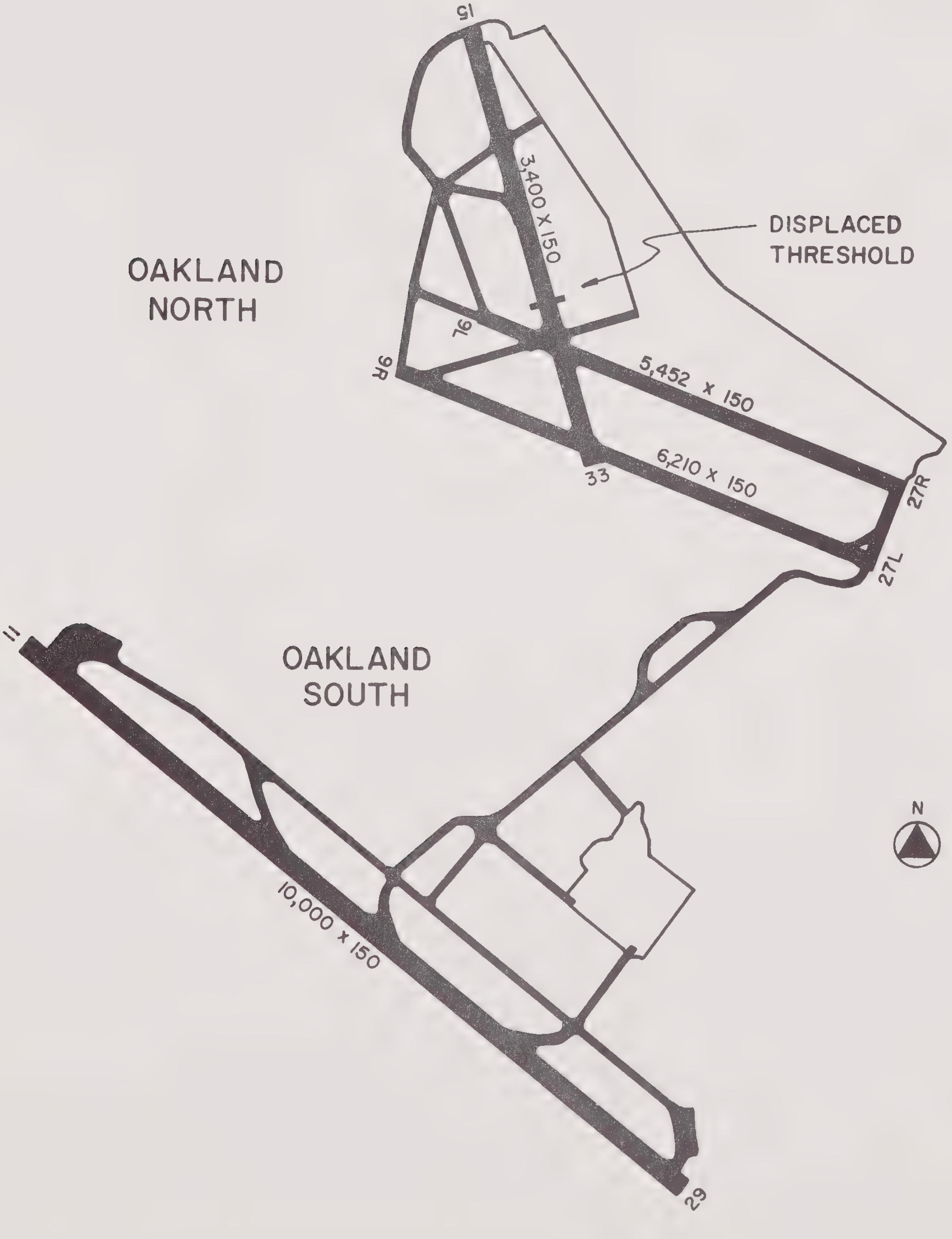
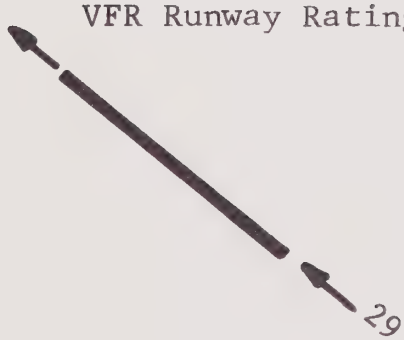
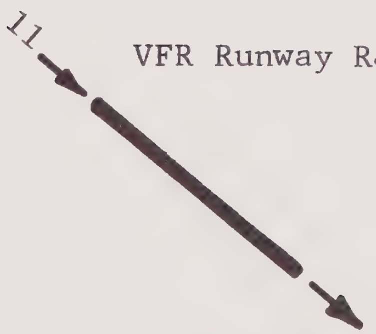


FIGURE 4-7

# RUNWAY CAPACITY OAKLAND SOUTH

| | PHOCAP | | Percent Use | |
|---|---|---|---|---|
| | VFR | IFR | VFR | IFR |
| VFR Runway Rating 49 | 48 | 42* | 79.5 | 4.0 |
| VFR Runway Rating 64 | 44 | 40* | 15.9 | .6 |
| | | | 95.4 | 4.6 |




* Inter-dependent with Oakland North and proportionate capacity assigned as shown

runways 27L-09R, 27R-09L and 15-33). Because of this independence, the two runway layouts are labeled Oakland South and Oakland North, and analyzed separately.

Aircraft population was computed from observations during field surveys, by review of FAA Form 7230-1, and briefings from controllers, fixed base operators and the airport manager. These sources of information were also utilized in determining touch-and-go data.

The population was determined to be:

| | Total % | Oakland South % | Oakland North % |
|---|---|---|---|
| Class A | 8 | 43 | - |
| Class B | 6 | 33 | - |
| Class C | 2 | 7 | 1 |
| Class D | 13 | 15 | 12 |
| Class E | 71 | 2 | 87 |

A weighted touch-and-go factor for Oakland North was derived from the following data:

- Monday-Friday touch-and-go average = 25%
- Saturday-Sunday touch-and-go average = 60%

5/7 by 25 = 17.85
2/7 by 60 = 17.14
34.99

- Weighted touch-and-go = 35%

It is important to recognize that capacity can become distorted by the touch-and-go operations. Each touch-and-go operation is counted as two movements by the FAA. Yet when analyzing its effect on capacity, we find a runway occupancy of 25 seconds, which is really only equivalent to about one-half to three-quarters of one normal arrival operation's occupancy time. Thus, a high percentage of touch-and-go operations results in a high arrival capacity, which can be misleading if its limitations are not recognized.

The annual capacity (PANCAP) will change as population changes. As general aviation aircraft operations decrease, and air carrier operations increase, the PANCAP will diminish (all other criteria remaining constant). This should be kept in

mind when using the PANCAPs derived for the present airport with its high percentage of general aviation traffic.

In the capacity computations, VFR operations are predicated on operating the runways as two distinct and separate configurations. General aviation has been assigned entire use of the Oakland North runway complex (see Figure 4-8), and a high percentage of air carrier operations are assigned to the longer single runway to the south - Oakland South.

IFR simultaneous approaches are not permitted on runways 27R and 29* because the runways are not parallel and the courses converge. Therefore, during IFR conditions, the entire complex is run as one airport, rather than the two independent airports analyzed for VFR conditions.

The hourly demand levels obtained from observations and recorded FAA data are:

HOURLY DEMAND LEVELS

| Hour | Ratio to Peak Hour | Hour | Ratio to Peak Hour |
|---|---|---|---|
| 0-2 | .04 | 12-14 | .89 |
| 2-4 | .02 | 14-16 | 1.00 Peak Hour |
| 4-6 | .04 | 16-18 | .85 |
| 6-8 | .26 | 18-20 | .62 |
| 8-10 | .58 | 20-22 | .42 |
| 10-12 | .91 | 22-24 | .23 |

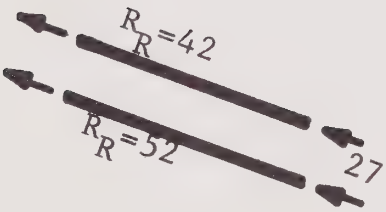
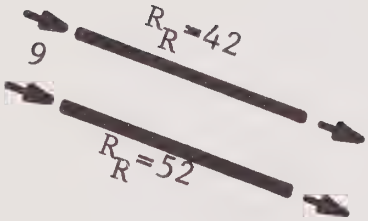
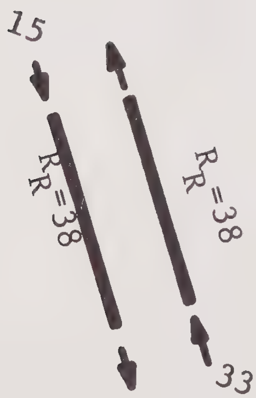
The daily demand levels were derived from the FAA forms 7230-1. The days of the year are sorted into nine levels of demand with the peak days given a ratio of 1.00 and other days shown as a ratio of the peak days. The following table indicates these levels and their proportionate occurrence during the year.

---

* Simultaneous approaches for 27R and 29 have been proposed, and at this time, the FAA-Washington is reviewing the proposal.

FIGURE 4-8

# RUNWAY CAPACITY OAKLAND NORTH

| | PHOCAP | | | Percent Use | |
|---|---|---|---|---|---|
| | Weighted Touch-&-Go | Zero Touch-&-Go | IFR | VFR | IFR |
|  | 180 | 120 | 22* | 78.4 | 4.0 |
|  | 180 | 120 | 22* | 15.5 | .6 |
|  | 98 | 84 | - | .7 | - |
| | | | | 94.6 | 4.6 |

$R_R$ = Runway Rating (VFR)

* Inter-dependent with Oakland South and proportionate capacity assigned as shown

DAILY DEMAND LEVELS

| Ratio to Peak Day | Annual Occurrence |
|---|---|
| 1.0000 | .0739 |
| .8808 | .1425 |
| .8146 | .0356 |
| .9284 | .1398 |
| .8403 | .2849 |
| .7927 | .0713 |
| .7940 | .0739 |
| .6661 | .1425 |
| .6269 | .0356 |
| 7.3438 | 1.0000 |

The above demand levels are developed from the composite traffic on both Oakland North and South. Since the population indicated some 85 percent general aviation traffic, the demand levels can be considered applicable to the Oakland North complex which is used by general aviation. The PANCAP capacity computation used these demand statistics to develop an annual utilization of 3,238 (this is the equivalent number of peak hours which occur in a year).

For the capacity computation of Oakland South (largely air carrier traffic), demand statistics had to be assumed since those above are more characteristic of general aviation traffic. Accordingly, typical hourly demand for a heavily loaded air carrier airport was used as follows:

HOURLY DEMAND LEVELS

| Hour | Ratio to Peak Hour | Hour | Ratio to Peak Hour |
|---|---|---|---|
| 0-2 | .10 | 12-14 | .75 |
| 2-4 | .10 | 14-16 | .95 |
| 4-6 | .15 | 16-18 | 1.00 Peak Hour |
| 6-8 | .40 | 18-20 | .75 |
| 8-10 | .65 | 20-22 | .50 |
| 10-12 | .75 | 22-24 | .30 |

The daily demand statistics for San Francisco International Airport were used as typical for the region and, therefore, also Oakland South.

Following is the annual capacity for the current runway layouts:

| | Demand* | Annual** Capacity | Peak Hour at PANCAP |
|---|---|---|---|
| Oakland South | 105,132 | 221,000 | 57 |
| Oakland North | 247,340 | 546,000 | 170 |

* 12 month total, April 1969 - March 1970 (with helicopter traffic excluded)

** It is noted that the Federal Aviation Administration has recently presented listings of airport capacity including somewhat different numbers than those above. It is understood the FAA numbers are for a more idealized airport and traffic situation than the current situation represented by the above capacities.

The previous section indicated that the existing airports can operate to capacity with the present runway layout and aircraft mix without airspace interaction between the major airports. However, to assure the full capacity at Oakland Airport, it is essential that Hayward Airport be limited to VFR operations. IFR operations at Hayward will seriously reduce the IFR capacity of the present Oakland Airport, and obviously be more serious if additional runways are built on Oakland Airport. Likewise, IFR operations at NAS Alameda will seriously reduce Oakland Airport capacity because of the proximity of the two facilities. In both cases of conflict, IFR approaches to either Alameda or Hayward will probably reduce Oakland capacity by an equivalent or greater number of operations.

## 4.7 - Capacity Analysis of San Jose Municipal Airport

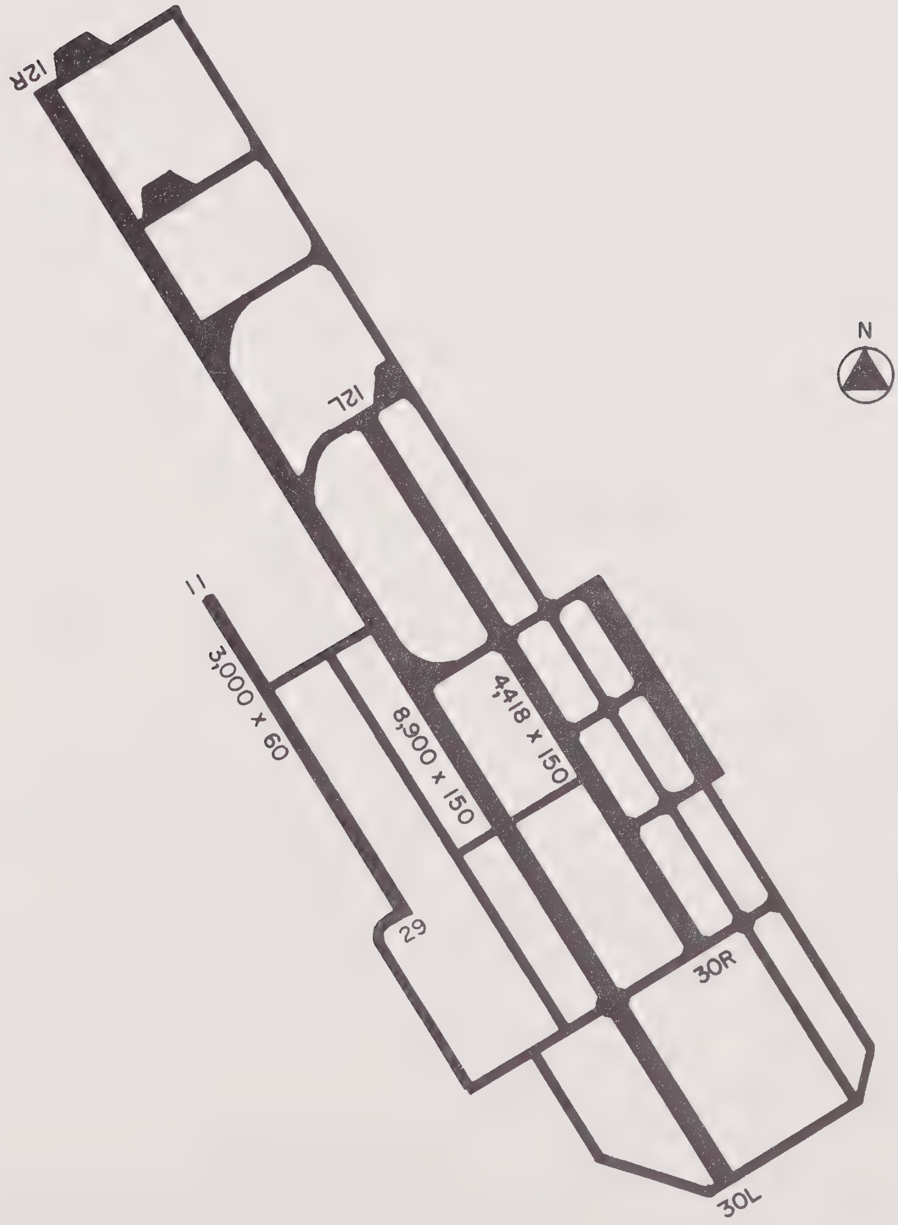
The airport is located at the south end of the San Francisco Bay. The airport has three parallel runways, the major two with centerline spacing of 750 feet. A schematic of the runways is shown in Figure 4-9. Runway 12R-30L is 8,900 feet and can accommodate all classes of aircraft. Runway 12L-30R is 4,419 feet and can accommodate Classes D and E aircraft, and most Class C aircraft. The third runway, 3,000 feet long, west of the first two is used for touch-and-go operations. The airport has an ILS approach to runway 30L and an ILS back course approach to runway 12R.

The aircraft population for all runways was determined by field observation as:

Class A - 1%
Class B - 9%
Class C - 3%
Class D - 12%
Class E - 75%

FIGURE 4-9

# SAN JOSE MUNICIPAL AIRPORT



A weighted touch-and-go factor was determined from field data, controller briefings, and consultation with fixed base operators and the airport manager as follows:

- Monday-Friday touch-and-go average = 41%
- Saturday-Sunday touch-and-go average = 62%

| | | |
|---|---|---|
| 5/7 by 41 | = | 29.28 |
| 2/7 by 62 | = | 17.71 |
| | | 46.99 |

- Weighted touch-and-go factor = 47%

At San Jose Municipal Airport, the touch-and-go operations warrant close attention when considering airport capacity. As indicated earlier, each touch-and-go is counted as two movements. The high percentage of touch-and-go indicated above will result in high capacities - but the capacity is mainly available for the training operation of light aircraft.

In VFR, two sets of population are used and assigned to runway use as follows:

- For runway 12R-30L:

| | | |
|---|---|---|
| Class A | - | 3% |
| Class B | - | 24% |
| Class C | - | 10% |
| Class D | - | 20% |
| Class E | - | 43% |
| | | 100% |

- For runway 12L-30R:

| | | |
|---|---|---|
| Class D | - | 8% |
| Class E | - | 92% |
| | | 100% |

The 11-29 strip is used only for touch-and-go traffic. In IFR, the runway equipped with ILS is used for low minimum approaches. During higher IFR weather, either runway can be used for landings, but from a common approach path.

IFR air carrier departures are handled on runway 12R-30L, whereas the general aviation departures are assigned either runway 12R-30L or runway 12L-30R; the overall result in capacity is the equivalent of a single runway with a plus factor.

Typical hourly demand levels were used inasmuch as the field observations indicated the airport is operating well below capacity, and therefore hourly counts are not too meaningful. Accordingly, a typical hourly demand for a lightly loaded airport was used in the following table.

HOURLY DEMAND LEVELS

| Hour | Ratio to Peak Hour | Hour | Ratio to Peak Hour |
|---|---|---|---|
| 0-2 | .05 | 12-14 | .65 |
| 2-4 | .05 | 14-16 | .80 |
| 4-6 | .05 | 16-18 | 1.00 Peak Hour |
| 6-8 | .25 | 18-20 | .65 |
| 8-10 | .60 | 20-22 | .35 |
| 10-12 | .70 | 22-24 | .10 |

The daily demand levels were derived from the FAA Forms 7230-1. The days of the year are sorted into nine levels of demand with the peak days given a ratio of 1.00 and other days shown as a ratio of the peak days. The following table indicates these levels and their proportionate occurrence during the year.

DAILY DEMAND LEVELS

| Ratio To Peak Day | Occurrence | Ratio To Peak Day | Occurrence |
|---|---|---|---|
| 1.00 | .0711 | .73 | .0711 |
| .93 | .1421 | .69 | .0711 |
| .83 | .0361 | .62 | .1442 |
| .89 | .1426 | .50 | .0352 |
| .84 | .2865 | 7.03 | 1.0000 |

These demand characteristics resulted in an annual utilization of 2,870 (this is the equivalent number of peak hours of traffic which occur in a year).

Figure 4-10 indicates runway use and hourly capacity. The annual capacity and current demand are:

CAPACITY SUMMARY

| Demand* | Annual** Capacity | Peak Hour at PANCAP |
|---|---|---|
| 411,152 | 515,000 | 213 |

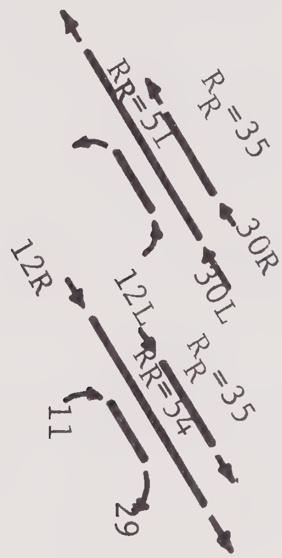
* 12 month total, April 1969 - March 1970 (with helicopter traffic excluded)

** It is noted that the Federal Aviation Administration has recently presented listings of airport capacity including somewhat different numbers than those above. It is understood the FAA numbers are for a more idealized airport and traffic situation than the current situation represented by the above capacity.

FIGURE 4-10

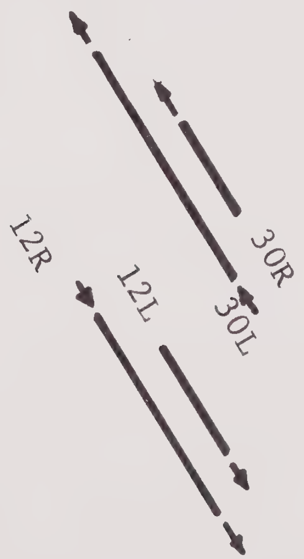
# RUNWAY CAPACITY-SAN JOSE

Runway Configuration VFR




| Percent Use | PHOCAPS Weighted T & G | PHOCAPS Zero T & G |
|---|---|---|
| 66.62 | **213*** | 145 |
| 23.55 | **213*** | 145 |

Runway Configuration IFR




| Percent Use | PHOCAPS |
|---|---|
| 7.30 | 59 |
| 2.53 | 60 |

* The short third parallel is used for touch and go only and is not loaded to capacity when the other runways reach capacity.

Of the above capacity, about 117,000 is assigned air carrier type aircraft. Greater numbers of air carrier aircraft can be accommodated, but the change in population would reduce overall capacity, and thus leave less capacity for general aviation.

## 4.8 - Capacity of General Aviation Airports

The 32 public use general aviation airports in the BASAR area have been evaluated as to capacity, their facilities, based aircraft, and other characteristics. The general description of each of these airports is included in Appendix E.

It is noted that the FAA has recently presented listings of airport capacity including somewhat different numbers than those below. It is understood the FAA numbers are for more idealized airports and traffic situations.

There are 14 private airports in the BASAR area which are listed and described in Appendix F. The following tables, one for each county, summarizes the capacity of the public use airports:

### ALAMEDA COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Livermore Municipal | 132 | 236,000 | 270,000 |
| Hayward Air Terminal | 192 | 363,000 | 284,000 |
| Fremont | 135 | 168,000 | 35,000 |
| Sky Sailing | 75 | 93,000 | 70,000 |
| | | 860,000 | 659,000 |

### CONTRA COSTA COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Antioch | 135 | 184,000 | 30,000 |
| Buchanan | 167 | 324,000 | 342,000 |
| | | 508,000 | 372,000 |

### MARIN COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Gnoss Field | 135 | 190,000 | 100,000 |
| Smith Ranch | 135 | 190,000 | 15,000 |
| | | 380,000 | 115,000 |

## NAPA COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Angwin | 101 | 126,000 | 20,000 |
| Calistoga Airpark | 122 | 168,000 | 10,000 |
| Napa County | 133 | 258,000 | 190,000 |
| Usibelli Restaurant | 135 | 168,000 | 3,000 |
| | | 720,000 | 223,000 |

## SAN FRANCISCO COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| None | - | - | - |

## SAN MATEO COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Half Moon Bay | 112 | 184,000 | 108,000 |
| San Carlos | 146 | 268,000 | 300,000 |
| | | 452,000 | 408,000 |

## SANTA CLARA COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Palo Alto | 130 | 239,000 | 191,000 |
| Reid-Hillview | 136 | 251,000 | 224,000 |
| Morgan Hill | 135 | 190,000 | 20,000 |
| | | 680,000 | 435,000 |

## SOLANO COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Nut Tree | 135 | 190,000 | 37,000 |
| Rio Vista Municipal | 135 | 250,000 | 11,000 |
| Vaca-Dixon | 132 | 171,000 | 5,000 |
| Vacaville | 135 | 168,000 | 10,000 |
| Maine Praire | 122 | 152,000 | 4,000 |
| Tremont | 122 | 152,000 | 10,000 |
| | | 1,083,000 | 77,000 |

SONOMA COUNTY

| Public Use Airports | PHOCAP | PANCAP | Demand |
|---|---|---|---|
| Sonoma County | 110 | 226,000 | 103,000 |
| Cloverdale Municipal | 135 | 222,000 | 12,000 |
| Healdsburg Municipal | 135 | 222,000 | 15,000 |
| Petaluma Sky Ranch | 135 | 250,000 | 52,000 |
| Santa Rosa Air Center | 135 | 190,000 | 24,000 |
| Santa Rosa Coddingtown | 135 | 250,000 | 70,000 |
| Sonoma Valley | 122 | 171,000 | 23,000 |
| Sonoma Sky Park | 122 | 152,000 | 10,000 |
| Sea Ranch | 135 | 168,000 | 2,000 |
| | | 1,851,000 | 311,000 |

## 4.9 - Comparison of Existing Capacity and Demand

The capacity of the general aviation public use airports in the nine counties is summarized in Figure 4-11 to permit a comparison of the available capacity to the estimated current demand. The current demand is determined from the tower records and other sources.

The annual capacities are compared to demand in Figure 4-12. General aviation is shown separate from air carrier. At the major airports a division was made for this comparison which assumed the percentage of air carrier to be 90 percent at San Francisco, 100 percent for Oakland South, and 30 percent of the long runway traffic at San Jose Airport.

Note that the summary shows an abundant capacity. However, the summing for the whole area can hide a disparity between capacity and demand in sections of the BASAR area. In general, it is found that the airports in built-up areas are more heavily loaded than those near the edge of the BASAR area.

## 4.10 - Airport Delay Characteristics

The annual delay (ANDE) characteristic is computed at various demand levels for the primary airports and for any general aviation airports operating above 75 percent capacity. Figure 4-13 lists the airports other than Oakland, San Francisco and San Jose that are operating above 75 percent capacity. Figure 4-14 tabulates the total annual hours of delay for these airports. These delay characteristics can be directly related to the cost/benefit resulting from new or proposed improvements to the runway and taxiway systems at the airports.

Figure 4-11

EXISTING PUBLIC USE AIRPORTS
CAPACITY SUMMARY FOR
GENERAL AVIATION

| | Annual Capacity |
|---|---|
| **Alameda Co.** | |
| Livermore | 236,000 |
| Hayward | 363,000 |
| Fremont | 168,000 |
| Sky Sailing | 93,000 |
| Oakland North* | 546,000 |
| Oakland South* | - |
| **Contra Costa Co.** | |
| Antioch | 184,000 |
| Buchanan | 324,000 |
| **Marin County** | |
| Gnoss Field | 190,000 |
| Smith Ranch | 190,000 |
| **Napa County** | |
| Angwin | 126,000 |
| Calistoga | 168,000 |
| Napa | 258,000 |
| Usibelli | 168,000 |
| **San Francisco Co.** | |
| None | 0 |
| **San Mateo Co.** | |
| Half Moon Bay | 184,000 |
| San Carlos | 268,000 |
| San Francisco* | 42,000 |

| | Annual Capacity |
|---|---|
| **Santa Clara Co.** | |
| Palo Alto | 239,000 |
| San Jose* | 398,000 |
| Reid-Hillview | 251,000 |
| Morgan Hill | 190,000 |
| **Solano County** | |
| Nut Tree | 190,000 |
| Rio Vista | 250,000 |
| Vaca-Dixon | 171,000 |
| Vacaville | 168,000 |
| Maine Prairie | 152,000 |
| Tremont | 152,000 |
| **Sonoma County** | |
| Sonoma Co. | 226,000 |
| Cloverdale | 222,000 |
| Healdsburg | 222,000 |
| Petaluma | 250,000 |
| Santa Rosa | 190,000 |
| Coddingtown | 250,000 |
| Sonoma Valley | 171,000 |
| Sonoma Park | 152,000 |
| Sea Ranch | 168,000 |
| Total Capacity | 7,520,000 |
| Total Without Three Major Airports | 6,534,000 |

* See Figure 4-12 for the assignment to general aviation for the major airports.

Figure 4-12

SUMMARY OF COMPARISON OF
GENERAL AVIATION AND AIR CARRIER
DEMAND AND CAPACITY

| | General Aviation | | Air Carrier | |
|---|---|---|---|---|
| | Demand | Capacity | Demand | Capacity |
| San Francisco | 37,050 | 42,000 | 333,435 | 382,000 |
| Oakland North | 247,340 | 546,000 | - | - |
| Oakland South | 48,327* | - | 56,805 | 221,000 |
| San Jose | 358,981 | 398,000 | 52,171 | 117,000 |
| General Aviation Public Use Airports | 2,600,000 | 6,534,000 | - | - |

Note: For demand at San Francisco Airport, 90 percent of the actual operations are shown as air carrier demand. For Oakland and San Jose, the actual air carrier tower count is shown as the air carrier demand, with the remainder of the tower count being assigned to general aviation.

* This number includes 32,435 general aviation plus air carrier training flights (15,892).

Figure 4-13

AIRPORTS AT OR ABOVE
75 PERCENT OF CAPACITY

| Airport | Demand 1/ | Present Capacity 2/ | Future Capacity 3/ | Percent 4/ Utilization (Present Capacity) | Percent 5/ Utilization (Future Capacity) |
|---|---|---|---|---|---|
| Livermore Mun. | 269,620 | 236,000 | 301,000 | 114.2 | 89.6 |
| Hayward Air Terminal | 283,912 | 363,000 | - 6/ | 78.0 | - |
| Buchanan Field | 341,907 | 324,000 | - 6/ | 100.8 | - |
| San Carlos | 300,000 | 268,000 | 375,000 | 111.0 | 80.0 |
| Palo Alto | 191,000 | 239,000 | 375,000 | 80.0 | 51.0 |
| Reid-Hillview | 224,367 | 251,000 | 339,000 | 89.5 | 66.2 |

1/ These are the 1968 figures.

2/ These capacity figures include an average percentage of touch-and-go movements.

3/ Future capacity available if the expansion plans on the airport master plans are implemented.

4/ Demand/present capacity.

5/ Demand/future capacity.

6/ No future expansion planned of operational areas.

Figure 4-14

DELAY CHARACTERISTICS - EXISTING AIRPORTS

| Airport | Demand | Annual Hours Delay |
|---|---|---|
| Livermore | 175,000 | 773 |
| | 200,000 | 1,063 |
| | 250,000 | 1,853 |
| | 300,000 | 3,914 |
| Hayward | 300,000 | 1,001 |
| | 350,000 | 1,511 |
| | 375,000 | 1,630 |
| | 400,000 | 1,899 |
| Buchanan | 275,000 | 1,009 |
| | 300,000 | 1,227 |
| | 340,000 | 1,665 |
| | 375,000 | 2,166 |
| San Carlos | 250,000 | 1,027 |
| | 265,000 | 1,185 |
| | 275,000 | 1,247 |
| | 350,000 | 2,128 |
| Palo Alto | 225,000 | 1,012 |
| | 240,000 | 1,150 |
| | 325,000 | 3,096 |
| | 375,000 | 6,356 |
| Reid-Hillview | 225,000 | 961 |
| | 251,000 | 1,204 |
| | 300,000 | 2,008 |
| | 350,000 | 3,700 |

| Airport | Demand | Annual Hours Delay |
|---|---|---|
| San Francisco | 375,000 | 6,423 |
| | 400,000 | 8,610 |
| | 424,000 | 12,000 |
| | 450,000 | 18,375 |
| | 475,000 | 28,047 |
| San Jose | 375,000 | 2,989 |
| (Demand shown does | 390,000 | 3,330 |
| not include T&G) | 425,000 | 4,388 |
| | 450,000 | 5,524 |
| | 475,000 | 7,043 |
| Oakland North | 325,000 | 1,569 |
| (Demand shown does | 367,000 | 2,090 |
| not include T&G) | 400,000 | 2,647 |
| | 425,000 | 3,182 |
| | 450,000 | 3,876 |
| | 475,000 | 4,788 |
| Oakland South | 175,000 | 2,620 |
| | 200,000 | 4,000 |
| | 221,000 | 6,314 |
| | 250,000 | 12,760 |
| | 275,000 | 22,000 |

# 5. FORECAST OF FUTURE TRANSITION AIRSPACE LOADING

*******************************************************

The earlier text indicated that the current airport and airspace system is not seriously loaded. An examination of future loading has been accomplished. This section discusses the transition airspace - that airspace generally described as the airspace where climb to, or descent from enroute altitude occurs. It will encompass a large geographic area - maybe 100 miles square, and centered on the BASAR area. The next section will discuss the airports and the low altitude airspace near the airports used for maneuvering for landing and takeoff.

To examine transition airspace loading for the future, a Speas Associates' model was used which is briefly described below. A more complete description is included as Appendix D.

## 5.1 - Transition Airspace Analysis Model

The Transition Airspace (TRANSAIR) computer model has been developed by the consultants personnel to analyze the terminal area transitional airspace. The TRANSAIR model can encompass air route layouts which cover an area of over 100 miles in each direction, and up to an altitude of 50,000 feet. The complexity of controlling traffic within the transitional area, and enroute airway structure, is determined by this steady state model. It evaluates the aircraft transiting each airway intersection, their relation to other aircraft, and the complexity of providing separation to that traffic.

The user of the model must describe the airway structure, the number, routing and kind of aircraft using the airways, and the airport of departure or origination. The results are the complexity ratings for each airway intersection. Examples are included in the following text.

The TRANSAIR model has been used in several studies of conventional and STOL type traffic and on a study to evaluate the effect of air traffic control system improvements. The application here is to determine possible transition airspace constraints on the BASAR airport facilities development plans.

The usual procedure in applying the TRANSAIR model is to first analyze the present airspace operation. This serves two purposes - to familiarize the users with the existing air traffic operation, and to provide a comparative base and rough validation before applying the future air traffic system operation.

## 5.2 - Current Air Traffic Loadings

Earlier text described the work done to gain an understanding of the Bay Area air traffic network through observations, analysis, and discussions with air traffic control personnel. In addition, the twenty-four hour record of IFR aircraft operations in the Bay Area was obtained for 30 July 1969. These records were in the form of flight progress data strips used by the ARTC center. One or more strips are made out for each IFR operation. They contain the actual point to point flight information for every aircraft operating on an IFR flight plan - such as time at fix, altitude, aircraft type. The strips were separated by hour of day, and then four consecutive busy hours were selected which were from 2000 to 2400 GMT (1 to 5 PM PDST).

The strips were sorted and analyzed to create a record of current airspace usage. This included origination and destination information, aircraft model, planned routes, and user (airline, general aviation or military). All airports in the study area with IFR flight operations in progress were included in the analysis.

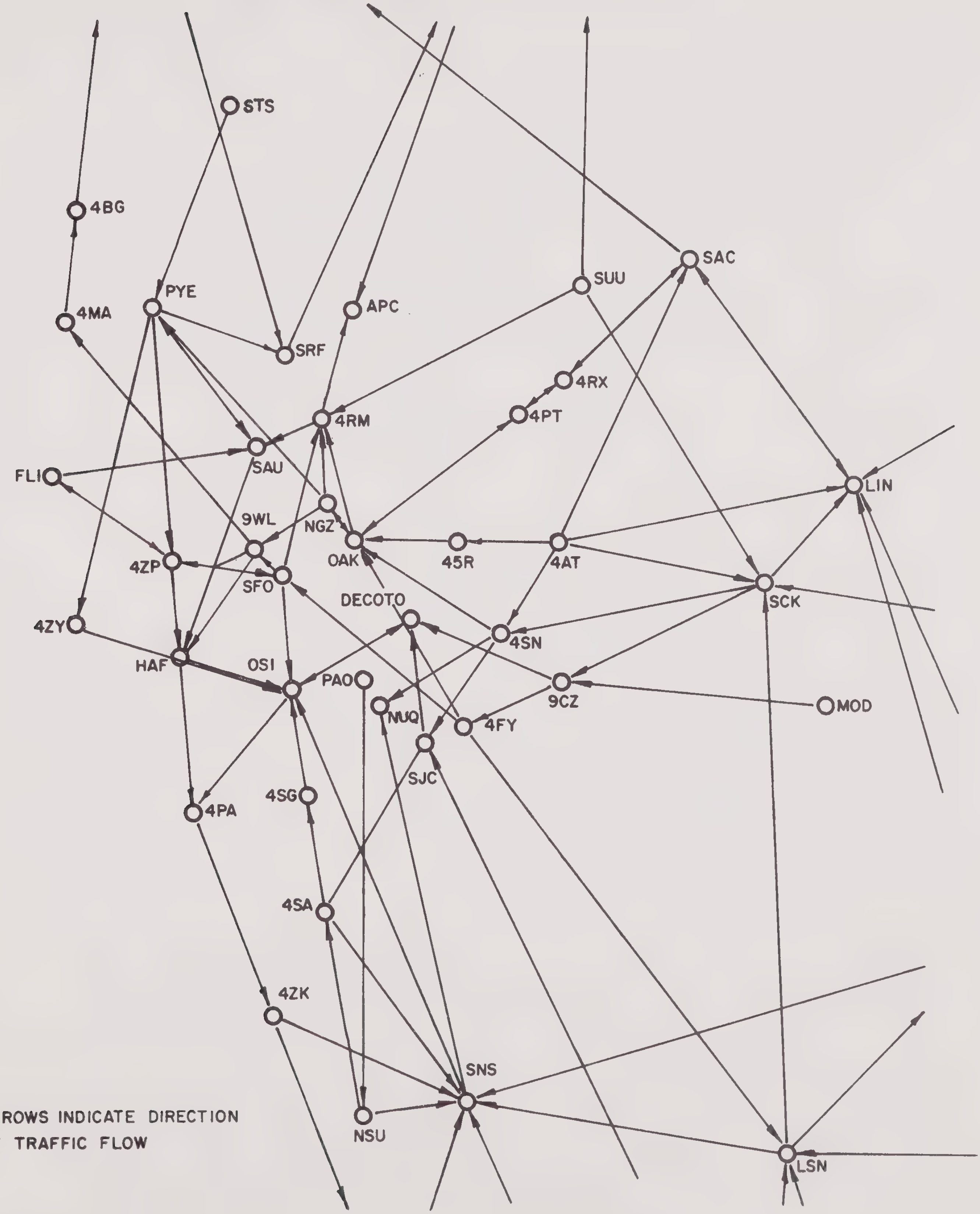
A map of the routings used was developed as shown in Figure 5-1. Four categories of routes are shown by the arrows - aircraft originating in the area to destinations outside, aircraft arriving in the area from origination outside, over-flights with no arrival or departure in the area, and intra-area, i.e. flights originating and terminating totally within the area.

To give an indication of scope, the list below is the airports with traffic in the sample, and which were close enough to BASAR airports that aircraft were in climb or descent to them. In addition, the traffic sample included aircraft en-route to/from 30 other airports. Airports in the BASAR area are marked with an asterisk.

| | | |
|---|---|---|
| *Alameda N.A.S. | Lemoore | Sacramento Exec. |
| Arcata | Mather AFB | Sacramento Met. |
| Avenal | McClellan AFB | Salinas |
| Bakersfield | Modesto | *San Carlos |
| Beale AFB | *Moffett N.A.S. | *San Francisco |
| *Buchanan | Monterey | *San Jose Mun. |
| Castle AFB | *Napa Co. | San Luis Obispo |
| Chico | *Oakland | Santa Barbara |
| Edwards AFB | *Palo Alto | Santa Maria |
| Fresno | Paso Robles Co. | *Santa Rosa Sonoma Co. |
| *Hamilton AFB | Porterville | Stockton |
| *Hayward | Red Bluff | *Travis AFB |
| Lake Tahoe | Redding | |

FIGURE 5-1

# BASAR TRANSAIR MAP
# ROUTES AND INTERSECTIONS




ARROWS INDICATE DIRECTION OF TRAFFIC FLOW

The most of the traffic is at the major airports, for out of the total traffic sample of 428 in four hours, the following were assigned:

| | | |
|---|---|---|
| San Francisco | - | 175 |
| Oakland | - | 26 |
| San Jose | - | 30 |
| Military | - | 129 |
| Other Airports | - | 68 |
| Total | - | 428 |

The traffic sample was taken before the installation of new standard routes (SID's and STAR's) during August. However, the sample was adjusted to apply to the new standard routes.

The existing aircraft population, as determined from survey and as described to the model was:

TRANSITION AREA AIRCRAFT POPULATION

| | |
|---|---|
| A = 40% | D = 2% |
| B = 40% | E = 3% |
| C = 15% | |

This includes military, as well as civil, flights.

Because the TRANSAIR model computes climb and descent profiles, the aircraft type must be specified more accurately than in the above listing. This was accomplished by use of the strip sort information and judgment to further assign the aircraft into performance types related to strip length as well as aircraft type. The TRANSAIR model has in its memory the characteristics of 25 aircraft types to cover this more detailed performance need.

## 5.3 - Results of Current Airspace Analysis

The TRANSAIR model results are presented as the complexity rating for control of traffic at airway intersections. Before examining results, it is well to indicate the relative meaning of the complexity ratings.

Since 1965 the TRANSAIR model has been used several times in studies of New York and other areas. It has been concluded from these studies, that complexity rating totals approaching 1,000 deserve attention and efforts to prevent further increase in the rating. Relief can be provided by air traffic control system improvements, rerouting, and/or additional airways.

The calibration run of the TRANSAIR model of the existing airspace system shows no critical points with a complexity of more than 500. This should not be disappointing for it shows that the present control of the airspace is well organized. It also emphasizes that much of the air traffic does not enter the enroute ATC system, as the predominance of good flying weather supports a considerable number of VFR flight operations.

VFR traffic creates an undefined loading of another kind. The controller directing traffic in a radar environment must constantly advise the aircraft being controlled of all targets in the vicinity of the aircraft, even though the targets are training aircraft making training flights, locally about an airport. Many VFR training patterns are evident in the radar analyses shown in the earlier discussions.

There are, however, several intersections with relatively high complexities which reflect the origin-destination pairing within the Bay Area.

- Sacramento has a complexity value of 462. This is the highest value, and is the result of the heavy exchange of traffic between the BASAR airports and the east.

- Salinas with the next highest rating of 313, reflects the airway loading for the traffic from the nine counties of BASAR to southern localities.

Both of these points are at the study area boundary.

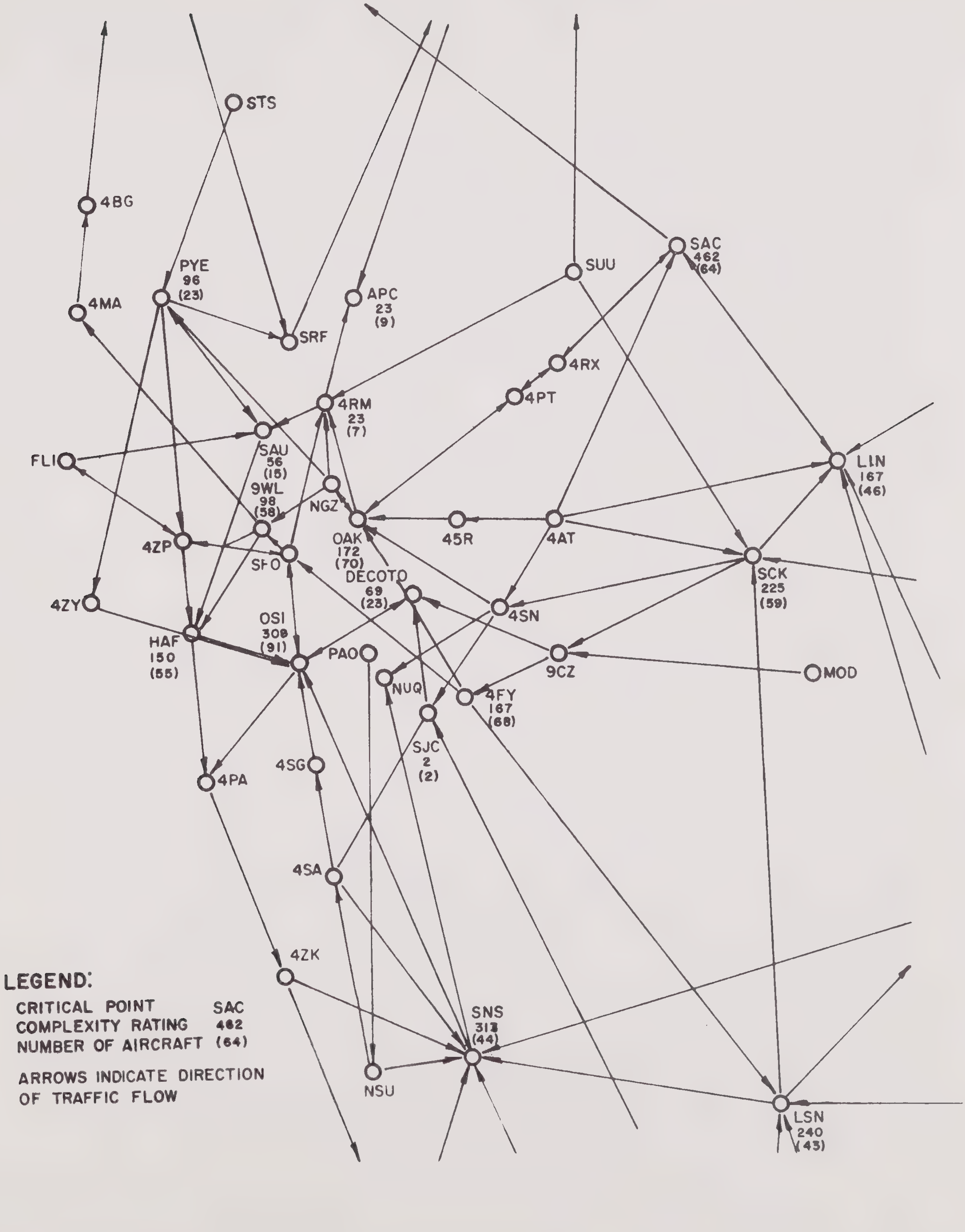
Woodside, a navigation facility from which arriving aircraft are directed to each of the primary airports, has a complexity of 308. This point is used in the current SID's and STAR's. Other SID-STAR interacting points are also in the calibration run of TRANSAIR, but have very low complexity values. The map in Figure 5-2 illustrates complexity loading for each intersection, the traffic through that intersection, and the total system complexity. Fortunately, the present system can accept much expansion of traffic before it is overloaded.

## 5.4 - Future Airspace Loading

The first run of the TRANSAIR computer program has shown a tolerable loading of the airspace with the existing airport system and traffic load. A test of the impact of future air traffic loading was made. An estimate of the capacity of the proposed development plans for Oakland, San Francisco and

FIGURE 5-2

# BASAR AIRSPACE CRITICAL POINTS PRESENT LOADING



San Jose Airports were used to develop the expanded demand on the system (capacity was estimated without any airspace limitations) as follows:

| | |
|---|---|
| Oakland | 880,000 |
| San Jose | 730,000 |
| San Francisco | 690,000 |
| Total | 2,300,000 |

The directional flow was assumed to remain the same for this simulated 1980 time period and all traffic was factored upward to reflect the assumed airport capacities. The total demand of 2,300,000 was used since there have been proposals to establish positive control areas in the Bay Area which would put all traffic from the major airports in the ATC system.

The above increase in traffic resulted in changes in the input to the TRANSAIR model (over the application to current traffic) which increased the four hour traffic total from 428 to 2,484 movements. The movements assigned were:

| | | |
|---|---|---|
| Three major airports | - | 2,033 |
| Other civil airports | - | 147 |
| Military airports | - | 304 |
| Total | | 2,484 |

The TRANSAIR model was applied using the routes and complexity criteria (ATC equipment and procedures) in effect today to provide a direct comparison with the current airspace loading.

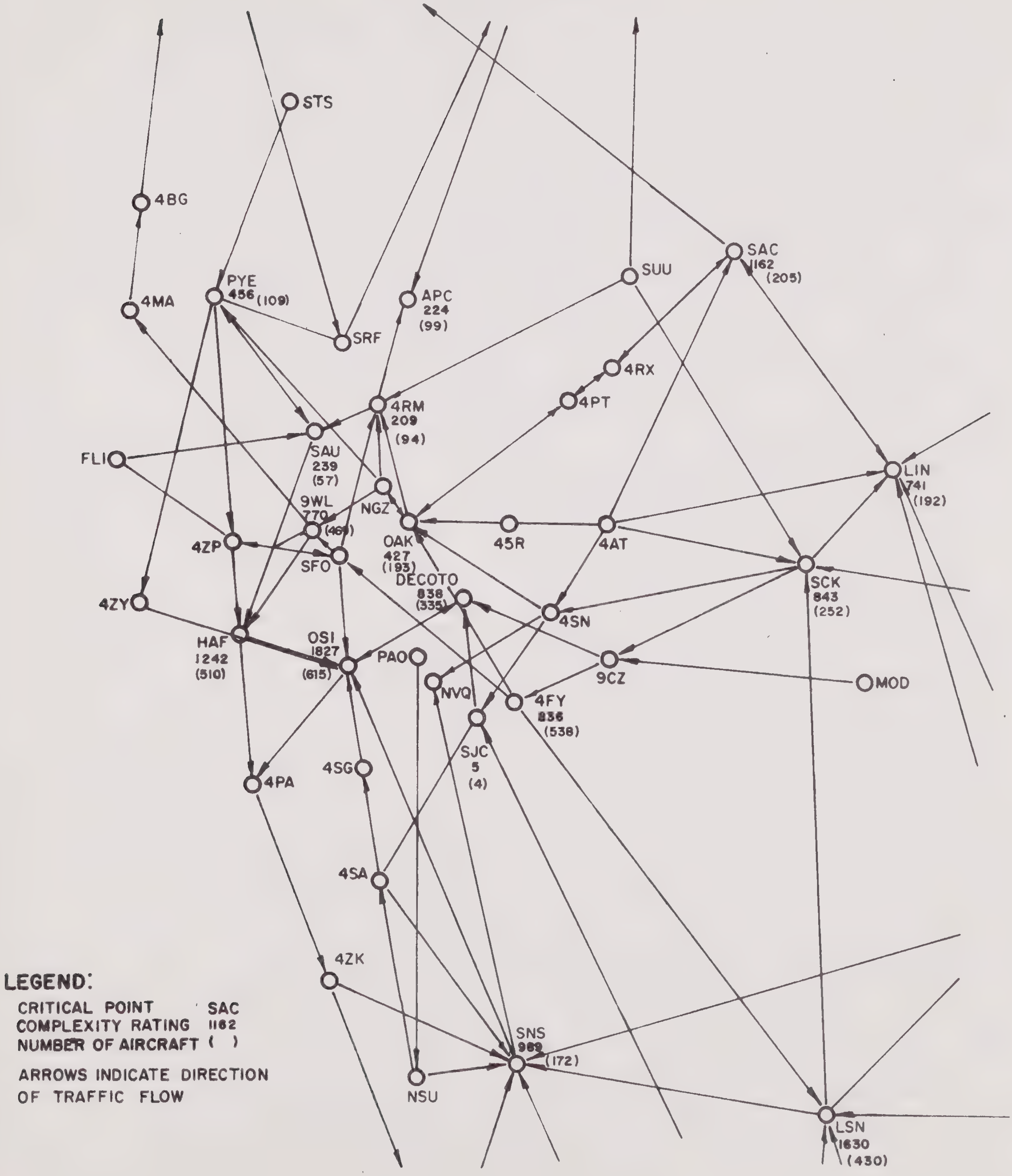
## 5.5 - Results of Future Airspace Analysis

The results of the TRANSAIR analysis with future loading is presented in Figure 5-3. Recall that the desired maximum complexity rating is 1,000 at a critical point, and that the maximum loading on any point in the current system is Sacramento with 462. Figure 5-3 shows four points over 1,000 with the most severely loaded being Woodside with 1,827. Thus, some serious overloading will occur unless plans are made to avoid it.

Fortunately, it is not difficult to foresee the planning needed to avoid overloading. Recall that the analysis of Figure 5-3 was made on the present airway structure (requiring point-to-point navigation) and with today's complexity criteria, which assumes today's ATC separation criteria and equipment. Thus, there are two courses of action to improve the situation.

FIGURE 5-3

# BASAR AIRSPACE CRITICAL POINTS FUTURE LOADING



- Provide additional air routes
- Improve ATC equipment and procedures

### 5.5.1 - Additional Air Routes

Today's air routes are based on the VORTAC navigation system. The airways permit their use with point-to-point navigation techniques which bring all traffic over the VORTAC stations. Area navigation capability, which is just beginning to come into use, will permit the use of routes parallel to, and offset from, today's routes - thus spreading the traffic, particularly away from the VORTAC stations. Thus, routes can be added in the future which can be used to spread traffic. Since this capability is principally in airborne equipment, this increase can be accomplished without major additions in ground facilities. The addition of routes results in some increase in total complexity because more airway intersection points are created. However, the reduction in loading at the overloaded critical points due to rerouting, much more than offsets the increase due to more intersections. A sizable reduction results.

An illustration of how much can be achieved in this manner can be obtained from a previous study, wherein the Speas Associates' staff (then a part of the AIL Division of Cutler-Hammer) analyzed the New York area in detail*. This study concluded, "Rerouting of arriving and departing aircraft in the terminal area to avoid loading some sectors more than others, may well offer the opportunity for increasing the traffic level up to nearly three-fold". We consider that appreciable gains can, and will, be made in providing additional routes and reducing airway loading in the BASAR area.

### 5.5.2 - Improved ATC Equipment and Procedures

The improved FAA program includes the addition of automatic altitude and identity readout and display, and metering and spacing in the terminal area (included

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* New York Airspace Loading and Configuration, July 1969, AIL Division of Cutler-Hammer, prepared for U.S. Department of Transportation on Contract DOT-OS-A9-046.

in the National Airspace System (NAS) and Automated Radar Traffic Control System (ARTS III)). The study of New York airspace referenced above also included evaluation of the benefit of these additions, and the benefit of later adding conflict detection and resolution.

Figure 5-4 is excerpted from that report to show the results. The report concluded "Equipment and techniques improvements will allow the air traffic control system to handle nearly three times the present manually performed tasks, in the course of implementation of NAS-II planning".

5.5.3 - Conclusion Regarding Future Airspace Loading

The TRANSAIR analysis of future traffic demand indicated that certain airway intersections would have approximately a 100 percent overload (two times the desired maximum). The above discussion has indicated the possibility that either additional routes and rerouting, or improved ATC equipment and procedures, will accomplish a nearly three-time increase in traffic handling capability*. Some of both routing improvement and ATC improvement will occur - area navigation and automatic altitude and identity readout are now being implemented.

Therefore, the conclusion regarding future airspace loading is that the transition and enroute airspace will not be a limit to the maximum development of airports as presently envisioned by BASAR.

It is suggested that in the Phase II BASAR study, when a preferred future airport system has been selected, and the future air traffic demand is available, that a transition airspace analysis again be accomplished, assuming reasonable ATC equipment improvements and routes.

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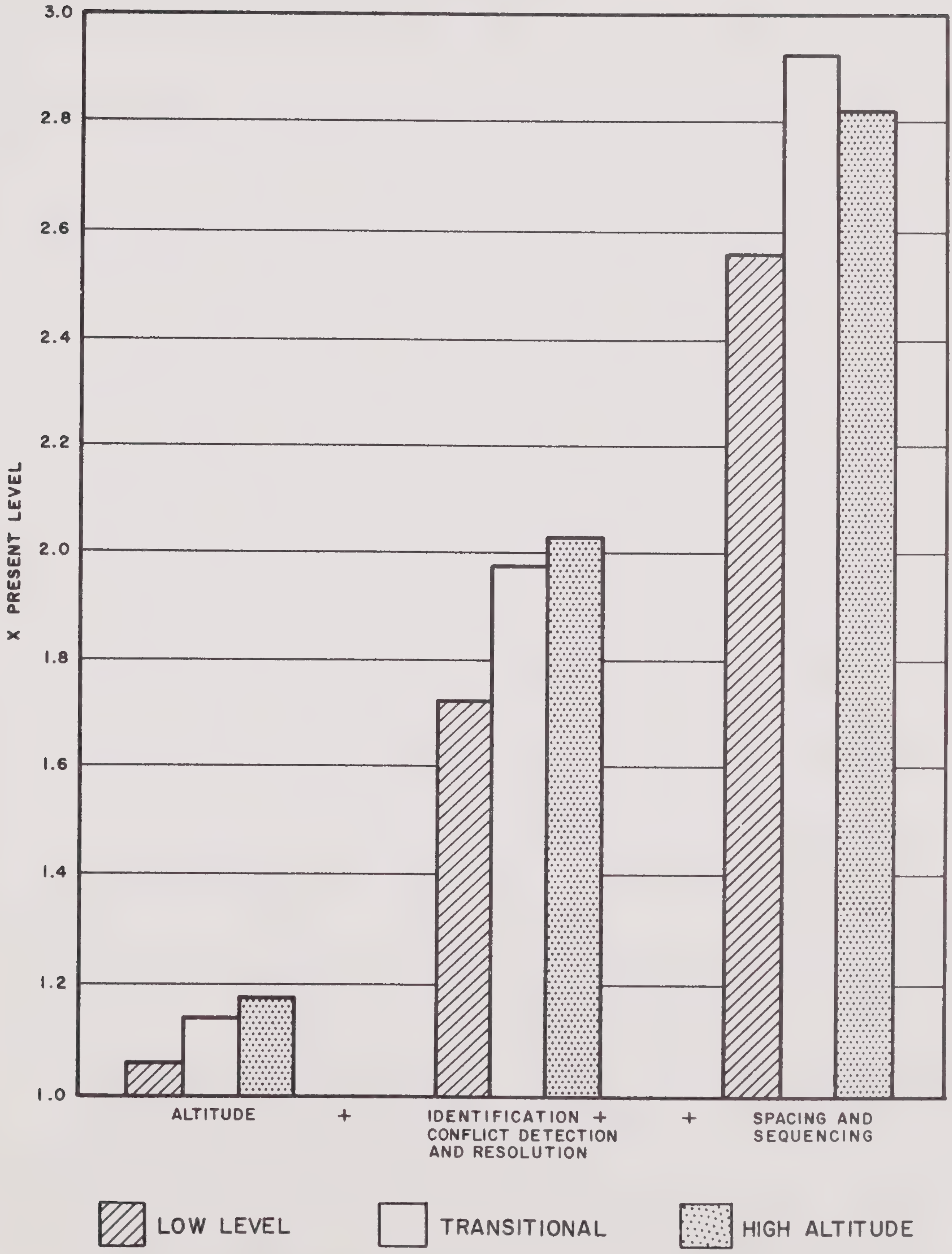
* This possible increase in capability has also been stated in the "Report of Department of Transportation Air Traffic Control Advisory Committee, Volume 1" which also stated "... it believes the results can be extrapolated to other regions".

Figure 5-4

INCREASE IN TRAFFIC LEVELS BY JURISDICTION
AND STAGED IMPROVEMENT



# 6. FORECAST OF THE FUTURE CAPACITY OF THE MAJOR AIRPORTS

**********************************

An examination of key aspects of future airport capacity was accomplished. This involved analysis of future capacity of the major airports with some alternate approaches to provide a first approximation of the inter-relationship between airports.

Master plan developments envisioned for the future for the three major airports were provided by the Study Director. The traffic forecast for use of the airports in the future was assumed as discussed below. Low altitude airspace and airport capacity were both analyzed to arrive at a total system capacity.

## 6.1 - Assumptions Regarding Airport Development and Traffic Forecasts

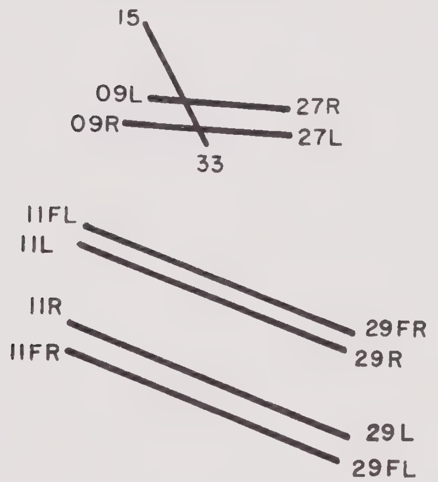
The schematic layout for the three BASAR major airports are shown in Figure 6-1. The Oakland Airport is proposed to have three air carrier runways added outboard and parallel to runway 11-29. One parallel is close to the present runway with the other two close parallel runways separated to permit simultaneous IFR operations and the development of a terminal area between the pairs of parallel runways. The development at San Francisco proposes the addition of a new runway outboard 5,000 feet from, and parallel to, the present 10-28 runways. The San Jose development plan includes a new airport (San Jose II) in proximity to the present airport. Several sites are being considered with the most critical from an airspace standpoint being that site furthest north. The present airport is to be kept for such general aviation operations as are feasible. The proposal is to examine a new airport called San Jose II in an area to the east of Moffett NAS. The study is to assume four 13-31 parallel air carrier runways separated for simultaneous operation on each of two pairs.

With the agreement of the Study Director, a future aviation demand was assumed to be the equivalent to the capacity of the airport development plans shown in Figure 6-1 (without regard to airspace restrictions). Since the aircraft population is necessary to airspace and capacity analysis, this was obtained by use of the FAA forecast, "Aviation Demand and Airport Facility Requirement Forecasts for Large Air Transportation Hubs Through 1980". The aircraft mix was developed from this 1980 forecast for the nine county study area as shown in the following.

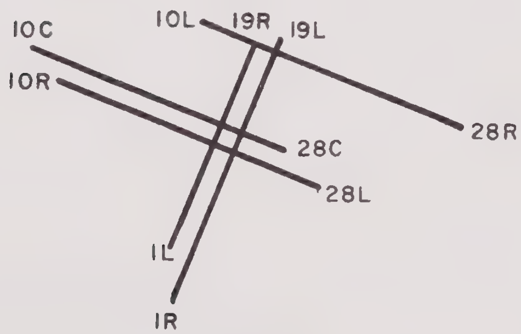
FIGURE 6-1

# AIRPORT DEVELOPMENT PLANS SCHEMATIC CONFIGURATIONS

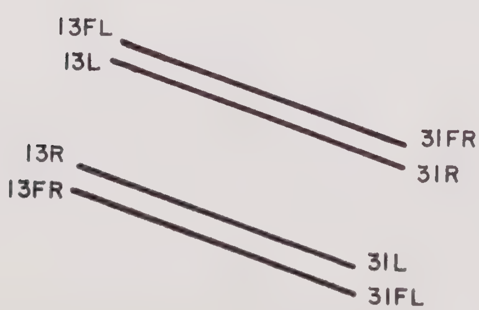
## OAKLAND




## SAN FRANCISCO




## SAN JOSE II



1980 AIRCRAFT POPULATION

| | |
|---|---|
| A = 32% | D = 18% |
| B = 15% | E = 24% |
| C = 11% | |

The consultant distributed this mix of aircraft to each of the airports in accordance with their future capacity using the primary airports first, and then assigned the demand that remained to other airports of the system. This procedure results in a high percentage of air carrier activity at the three major airports with a similar aircraft population for each airport as follows:

1980 PRELIMINARY POPULATION (PERCENT)

A+B = 85
C = 3
D = 7
E = 5

The hourly and daily demand statistics used for PANCAP computation were:

- San Francisco - that observed and used in Section 4.
- Oakland and San Jose - the demand used to compute Oakland South capacity in Section 4.

The direction of operation for the airport system was assumed to be that occurring at San Francisco International Airport.

## 6.2 - Airport Airspace Analysis

Previous analysis concluded that the transition area airspace will not limit BASAR airport capacity if ATC is properly developed. The airspace in the vicinity of the airports, which is used in maneuvering to land and takeoff, must also be analyzed to determine whether each airport has adequate airspace so capacity is not restricted. Analysis of this airspace can be described as analysis of airport approach and departure paths.

The airspace requirement for approach and departure is discussed below, and indications are given of the reduction in capacity when conflicts occur. Following that, each of the primary airports is discussed to show where airspace problems do occur.

## 6.2.1 - Operational Factors Involved

The initial departure and final approach portion of itinerant flight, involves critical maneuvers and both track and altitude requirements are fixed. On initial departure, headings must be maintained for a time, and no restrictions can be placed on climb until reaching minimum altitudes. On final approach, arrivals must be aligned with the runway at altitudes consistent with reasonable descent rates. As an example, an approach using a three degree glide slope must be 1,560 feet above runway elevation and descending when five nautical miles (approximately outer marker location) from the runway threshold; 2,600 feet and descending at eight nautical miles; and 3,500 feet and descending at 11 nautical miles. Where two paths cross, vertical separation of at least 1,000 feet must be provided, and, in addition, a three mile buffer must normally be protected beyond the actual point of intersection. These are minimum requirements and demand precise navigation and traffic control techniques. Wherever site location and runway orientation provide greater distances than these minimums, greater flexibility exists in the traffic control function.

The close location one to another of multi-runway systems in the Bay Area, requires a very complex arrival-departure path layout for the future. Each primary airport must be examined for restrictions to capacity resulting from interacting airspace conflicts between airports.

## 6.2.2 - Factors Which Limit Capacity

### Flexibility in Departure Paths

Maintaining maximum departure capacity at airports requires sufficient airspace for aircraft to be able to depart straight out, or to turn a minimum of 45 degrees to either side of the runway heading as soon as a safe maneuvering altitude is reached. Any airspace restrictions requiring departures to maintain extended flight on runway headings or which restrict a turn to 45 degrees to only one side of the runway heading, will result in a reduction in departure capacity. These restrictions can be the result of terrain, proximity of other airports and noise considerations for populated areas.

## Arrival Feeder Fixes

Arrival feeder fixes can be defined as points in space, normally located within or adjacent to a terminal control area, from whence aircraft may initiate the approach and landing phase of their flight. Normally, air traffic control radar separation and guidance is substituted for procedural separation from arrival feeder fixes until a landing is assured or completed.

Ideally, arrival feeder fixes should be located at a point common to and equidistant from both ends of the primary instrument runway. Positioning of these fixes at such locations reduces disruptions to traffic flow caused by wind shifts of sufficient velocity to require a change of runway direction. Airports with parallel runways, capable of simultaneous operations, require a minimum of two arrival fixes - one for each runway. Each fix should be positioned in the manner discussed above.

## Length of Arrival Path

Arrival aircraft are radar directed from the arrival feeder fix in an elliptical pattern to interception of the final approach course outboard of the outer marker. The point of turn-on to the final approach course can vary from 8-23 nautical miles depending upon the number and configuration of runways, traffic volume and/or aircraft sequencing requirements. Terminal airspace restrictions which require extensive lengthening of the final approach path from the arrival feeder fix to the airport, will result in a quantitative reduction in airport capacity. Airspace restrictions placed upon radar vectoring areas to prevent conflict with arrival or departure paths of adjacent airports will also result in a reduction in capacity.

## Examples of Capacity Limitations

The reduction to capacity resulting from approach and departure restrictions can be quantified using the PHOCAP computer program (Appendix A) supplemented, if need be, by simulation techniques.

An example of the computation of departure limitations for IFR traffic at San Francisco shows the following serious decrease in capacity:

- Normal departure (free to turn either side or straight) - 68 movements per hour for parallel runways

| | | |
|---|---|---|
| . Restricted departure where turn to one side is prohibited | - | 63 movements per hour for parallel runways |
| . Highly restricted departure where straight out climb to five or more miles is required | - | 50 movements per hour for parallel runways |

Regarding arrival limitation, this is usually due to lack of vector space for parallel approaches. Thus, if approaches must follow in-trail from the feeder fix and cannot "path-stretch", their capacity will decrease in an amount increasing with the length of added path. For a large air carrier airport, this would typically be .4 movements per added mile of in-trail flight.

Because the study is examining future developments - possibly the 1980 time period - and in light of current developments toward positive control in terminal areas, the assumption has been made that positive control will be in effect at all three airports. Further, because of the predominance of air carrier type traffic, IFR procedures have been assumed in use all of the time, but with missed approach procedures in effect only when ceiling and visibility are 700 feet and/or two miles or less. This is not a serious capacity limitation, but it does make the use of the Oakland Airport easterly runways difficult.

The capacity analysis is being made for a future time period as 1980. Therefore, future techniques have been assumed. The main assumption here is that Computer Aided Approach Sequencing (CAAS) and reduced spacing will be used. These increase capacity over today's capacity by an appreciable amount due to both the closer spacing and delay sharing - the assigning of equal priority to arrivals and departures so that arrivals can be delayed when needed to obtain optimum spacing for departure release ahead of arrival aircraft. An example of the increased capacity would be IFR operations on close parallel runways which today would have an hourly capacity of about 60, but with CAAS and reduced spacing would have a capacity of about 80.

## 6.3 - Alternate System Plans Considered

The airport-airspace analyses have shown serious conflict between the Bay Area airports. Consequently, in order to

provide BASAR with an adequate basis for considering system possibilities, the capacity has been determined from three standpoints. Where airspace conflicts exist, airports have been given priority in the order.

- 1st Case - San Francisco, Oakland/San Jose
- 2nd Case - Oakland, San Jose/San Francisco
- 3rd Case - San Jose, San Francisco/Oakland

Thus each major airport can see the capacity effect on it when it is prime or when it is secondary.

Before presenting the analysis results, it may be well to indicate why and where conflicts occur. Figures 6-2 and 6-3 indicate the locations where conflicts occur. For westerly operations, which predominate, the major conflict is between Oakland and San Francisco arrivals, and San Jose departures. For easterly operations, the major conflict is between San Jose arrivals and Oakland departures. These conflicts are evaluated in the following text.

## 6.4 - Case 1 - San Francisco Airport with Priority

The conflicts and limitations are discussed below and tabulated with the resulting capacities in Figure 6-4.

### 6.4.1 - San Francisco Airport

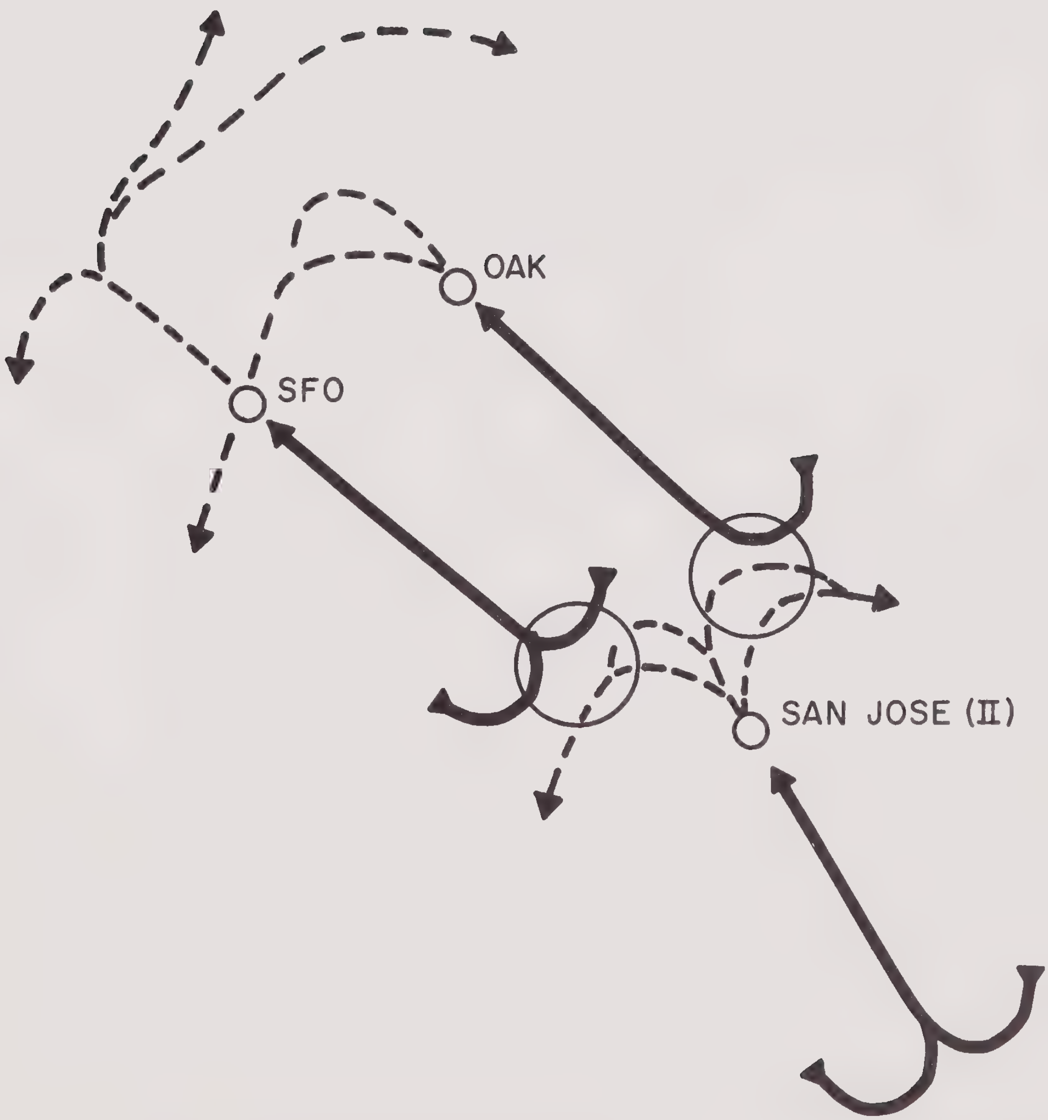
The major limitation on San Francisco is one due to terrain - the departure limitation due to terrain for takeoff to the northwest. For all weather not requiring missed approach protection, it is considered that a reasonable departure capacity can be achieved - 50 per hour. Runway 28C will be the main departure runway with some departures occurring on 28R. However, when a missed approach must be protected, the capacity decreases to that achievable with a single runway departure capability, with highly restricted airspace - or 38 per hour for 3.7 percent per year.

A lesser restriction occurs on departures to the southeast (runway 10), where departures must proceed straight-out further than the minimum required due to community noise considerations.

It should be noted that on the layout analyzed (Figure 6-1) the new runway (10L-28R) crosses the existing 01-19 runway. If the runway combination most favored

FIGURE 6-2

# BASAR AIR TERMINALS
# WESTERLY OPERATIONS




LEGEND

DESIRED APPROACH PATHS

DESIRED DEPARTURE PATHS

CONFLICT AREAS

FIGURE 6-3

# BASAR AIR TERMINALS EASTERLY OPERATIONS

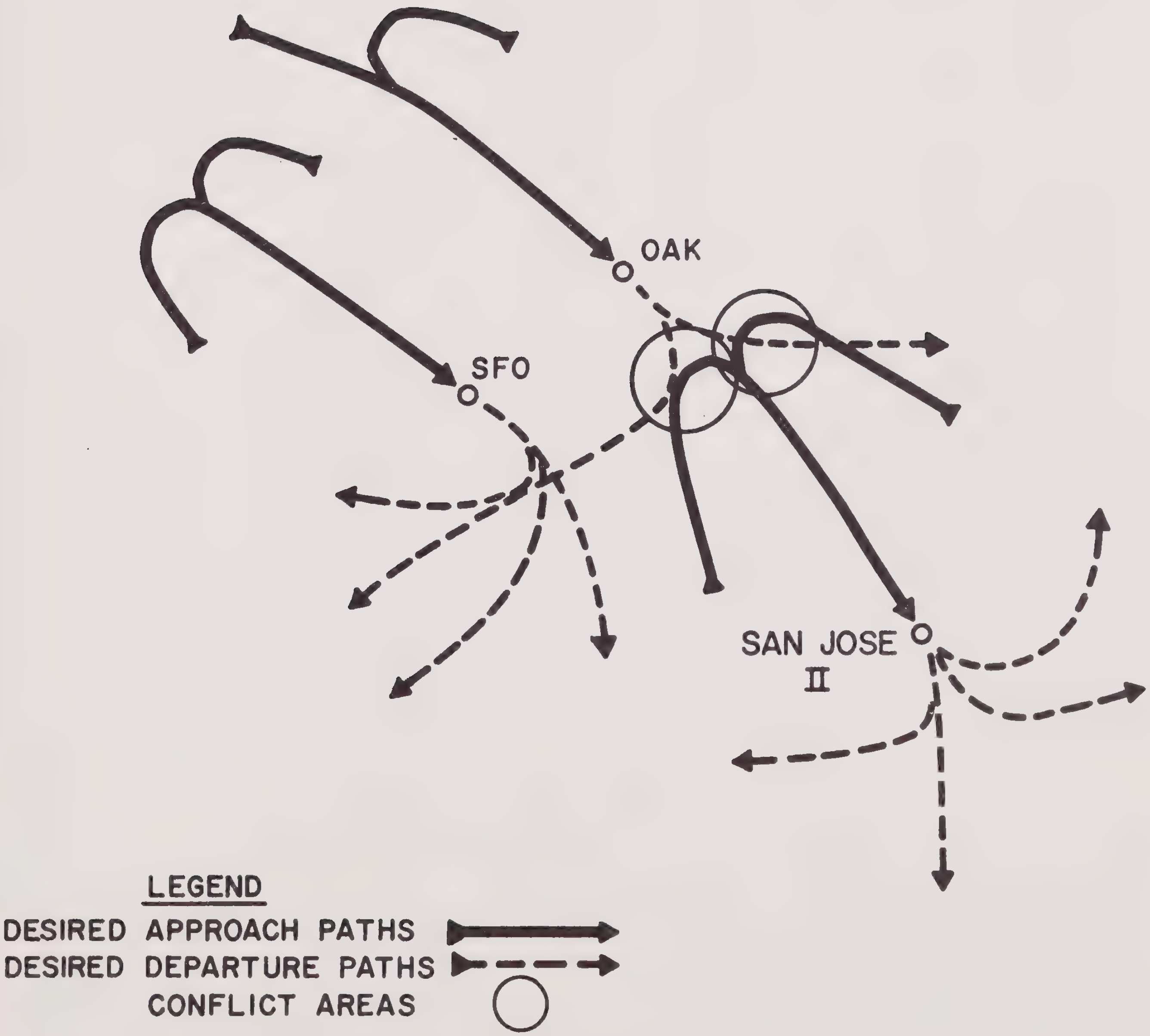


Figure 6-4

CAPACITY ANALYSIS CASE 1 - SAN FRANCISCO WITH PRIORITY

| Airport | Runway Number | Percent Use | Limitation | | Practical Hourly Capacity | | |
|---|---|---|---|---|---|---|---|
| | | | Approach | Departure | Arrival | Departure | Total |
| San Francisco | 28 | 83 | N | HR | 82 | 50* | 100 |
| | 10 | 15 | N | R | 82 | 63 | 126 |
| Oakland | 29 | As | N | R | 80 | 84 | 160 |
| | 11 | Above | N | HR | 80 | 64 | 128 |
| San Jose II | 31 | As | N | HR | 82 | 32 | 64 |
| | 13 | Above | Limited to 1 Approach | N | 41 | 82 | 82 |

N = Normal airspace
R = Restricted airspace
HR = Highly restricted airspace

* When the weather minimums require protection for a missed approach (3.7 percent), departure capacity drops to 38 per hour.

for noise abatement (01 and 28) is to be continued, it would be desirable to construct the new runway further to the east to avoid the physical intersection with the 01-19 runways.

### 6.4.2 - Oakland Airport

Oakland Airport for runway 29 operations has departures restricted because a right turn out is not desirable in order to avoid built-up areas and terrain. Runway 11 departures are highly restricted, being limited to a southeasterly direction by San Francisco traffic.

### 6.4.3 - San Jose II Airport

San Jose departures on runway 31 are highly restricted by the Oakland arrival airspace needs. Runway 13 operations are restricted on landing to a degree that only one landing runway and approach is usable.

## 6.5 - Case 2 - Oakland Airport with Priority

The conflicts and limitations are discussed below and tabulated with the resulting capacities in Figure 6-5.

### 6.5.1 - Oakland Airport

Operation on runway 29 is limited as in Case 1, by departure restrictions due to not using a right turn in order to avoid built-up areas and terrain.

Operation on runway 11 could be unrestricted, but if it were, no IFR arrival traffic could operate into San Jose. Therefore, to keep San Jose open, Oakland departures have been restricted to permit San Jose an arrival path.

### 6.5.2 - San Jose II Airport

Here, as in Case 1, departures on runway 31 are highly restricted by the Oakland arrival airspace needs. Runway 13 operations are restricted on landing to a degree that only one landing runway and approach is usable.

### 6.5.3 - San Francisco Airport

The analysis is as in Case 1, except that runway 10 departures are further restricted since a turn to

Figure 6-5

CAPACITY ANALYSIS CASE 2 - OAKLAND WITH PRIORITY

| Airport | Number | Percent Use | Limitation | | Practical Hourly Capacity | | |
|---|---|---|---|---|---|---|---|
| | | | Approach | Departure | Arrival | Departure | Total |
| San Francisco | 28 | 83 | N | HR | 82 | 50** | 100 |
| | 10 | 15 | N | HR | 82 | 51 | 102 |
| Oakland | 29 | As | N | R | 80 | 84 | 160 |
| | 11 | Above | N | R* | 80 | 74 | 148 |
| San Jose II | 31 | As | N | HR | 82 | 32 | 64 |
| | 13 | Above | Limited to 1 Approach | N | 41 | 82 | 82 |

N = Normal airspace
R = Restricted airspace
HR = Highly restricted airspace

* To remove the restriction on this departure situation would prohibit IFR arrivals at San Jose II, so the rating shown was chosen to permit operations at San Jose.

** When the weather minimums require protection for a missed approach (3.7 percent) departure capacity drops to 38 per hour

the east is not permissible due to Oakland priority on that airspace.

## 6.6 - Case 3 - San Jose II Airport with Priority

The conflicts and limitations are discussed below and tabulated with the resulting capacities in Figure 6-6.

### 6.6.1 - San Jose II Airport

No restrictions are indicated and, therefore, a high capacity results.

Here it may be well to comment on the future of present San Jose Airport with San Jose II developed. The above discussion abundantly indicates the heavy airspace loading which the future system will have. Although the present San Jose site is south of the major complex of airports, any attempt to operate it as an IFR airport will add to the total complexity and will seriously interfere with San Jose II operations. It is considered that the present San Jose Airport could only remain in operation as a VFR airport, but with rather strict control of local airport patterns.

### 6.6.2 - San Francisco Airport

Giving San Jose Airport departures the priority on airspace means the vector space available to San Francisco arrivals on runway 28 is limited. Consequently, an arrival capacity reduction must be made.

Further, runway 10 departures remain highly restricted as a turn to the east is not permitted. If the turn were permitted, it would "bottle up" Oakland departures completely. Therefore, to permit Oakland to have one highly restricted departure route, San Francisco is shown with a further restriction on departures.

### 6.6.3 - Oakland Airport

Oakland arrivals on runway 29 must be limited to "in trail" operation with no vector area in order to give San Jose departures priority. Thus, a capacity reduction on arrivals occurs.

On runway 11 operation, departures are highly restricted due to the priority of San Jose arrivals.

Figure 6-6

CAPACITY ANALYSIS CASE 3 - SAN JOSE II WITH PRIORITY

| Airport | Runway Number | Percent Use | Limitation | | Practical Hourly Capacity | | |
|---|---|---|---|---|---|---|---|
| | | | Approach | Departure | Arrival | Departure | Total |
| San Francisco | 28 | 83 | HR | HR | 69 | 50* | 100 |
| | 10 | 15 | N | Limit to 1 HR Runway | 82 | 38 | 76 |
| Oakland | 29 | As Above | HR | R | 69 | 84 | 138 |
| | 11 | | N | Limit to 1 HR Runway | 80 | 38 | 76 |
| San Jose II | 31 | As Above | N | N | 82 | 82 | 164 |
| | 13 | | N | N | 82 | 82 | 164 |

N = Normal airspace
R = Restricted airspace
HR = Highly restricted airspace

* When the weather minimums require protection for a missed approach (3.7 percent) departure capacity drops to 38 per hour.

## 6.7 - IFR Operation of Other Airports

The above discussion indicates the serious airspace loading problems resulting from operation of the expanded three major airports. No provision has been made for IFR operation of military airports or general aviation airports. Substantial IFR operation at either NAS Moffett or NAS Alameda will cause further airspace problems. General aviation IFR operations at Hayward Airport will interfere with the maximum development of both Oakland and San Jose II Airports.

Thus, the Phase II study of alternatives should include realistic assumptions for IFR operations to be assigned airports throughout the BASAR area.

## 6.8 - Future System Capacity

Using the results of the analysis just completed, the practical annual capacity for the development plans of the three primary airports has been computed. Delay characteristics are presented for a demand range useful to cost/benefit analysis.

The practical annual capacities for the development plans at Oakland, San Francisco and San Jose II are tabulated in Figure 6-7. The future PANCAP for other public use airports are tabulated in Figure 6-8. The capacity of the system is summarized.

## 6.9 - Delay Characteristics - Future Airport Plans

Delay characteristics are presented (Figure 6-9 and 6-10) for the primary airports and for those of the other public use airports that currently have an annual traffic count (movements) exceeding 75 percent of the planned annual capacity as presented in Section 4. The range of demand/delay is useful to the airport planner who can relate hours of delay to the hourly cost of operating aircraft to determine when airport improvements should be undertaken.

Figure 6-7

ANNUAL CAPACITIES RESULTING FROM PROPOSED DEVELOPMENT AT PRIMARY AIRPORTS

Case 1 - San Francisco as the Primary Airport

| Airport | PHOCAP Range | PANCAP | Peak Hour |
|---|---|---|---|
| San Francisco | 126- 76 | 562,000 | 113 |
| Oakland | 160-128 | 695,000 | 176 |
| San Jose II | 82- 64 | 309,000 | 80 |
| | | 1,566,000 | |

Case 2 - Oakland as the Primary Airport

| Airport | PHOCAP Range | PANCAP | Peak Hour |
|---|---|---|---|
| Oakland | 160-148 | 725,000 | 184 |
| San Jose II | 82- 64 | 309,000 | 80 |
| San Francisco | 102- 76 | 557,000 | 112 |
| | | 1,591,000 | |

Case 3 - San Jose as the Primary Airport

| Airport | PHOCAP Range | PANCAP | Peak Hour |
|---|---|---|---|
| San Jose II | 164 | 768,000 | 195 |
| San Francisco | 100- 76 | 492,000 | 99 |
| Oakland | 138- 76 | 446,000 | 113 |
| | | 1,706,000 | |

Figure 6-8

PUBLIC USE AIRPORTS (GENERAL AVIATION)
CAPACITY SUMMARY (PROPOSED DEVELOPMENT)

| | Annual Capacity |
|---|---|
| **Alameda Co.** | |
| Livermore | 301,000 |
| Hayward | 363,000 |
| Fremont | 168,000 |
| Sky Sailing | 93,000 |
| **Contra Costa Co.** | |
| Antioch | 184,000 |
| Buchanan | 340,000 |
| **Marin County** | |
| Gnoss Field | 190,000 |
| Smith Ranch | 190,000 |
| **Napa Co.** | |
| Angwin | 126,000 |
| Calistoga | 168,000 |
| Napa | 258,000 |
| Usibelli | 168,000 |
| **San Francisco Co.** | |
| None | 0 |
| **San Mateo Co.** | |
| Half Moon Bay | 184,000 |
| San Carlos | 375,000 |

| | Annual Capacity |
|---|---|
| **Santa Clara Co.** | |
| Palo Alto | 375,000 |
| Reid-Hillview | 339,000 |
| San Jose Mun. | (see text) |
| Morgan Hill | 190,000 |
| **Solano County** | |
| Nut Tree | 190,000 |
| Rio Vista | 250,000 |
| Vaca-Dixon | 171,000 |
| Vacaville | 168,000 |
| Maine Prairie | 152,000 |
| Tremont | 152,000 |
| **Sonoma County** | |
| Sonoma Co. | 226,000 |
| Cloverdale | 222,000 |
| Healdsburg | 222,000 |
| Petaluma | 250,000 |
| Santa Rosa | 190,000 |
| Coddingtown | 250,000 |
| Sonoma Valley | 171,000 |
| Sonoma Park | 152,000 |
| Sea Ranch | 168,000 |

CAPACITY SUMMARY

| | |
|---|---|
| Above Airports | 6,946,000 |
| Primary Airports* | 1,500,000± |
| | 8,446,000± |

* The PANCAP of the primary airports varies with how the air-space conflict problems are resolved. Thus a minimum total for the three airports is shown.

Figure 6-9

DELAY CHARACTERISTICS - PROPOSED
GENERAL AVIATION AIRPORT PLANS

| Airport | Demand | Hours Delay |
|---|---|---|
| Livermore | 200,000 | 620 |
| | 250,000 | 947 |
| | 300,000 | 1,426 |
| | 350,000 | 2,134 |
| Hayward | 300,000 | 1,001 |
| | 350,000 | 1,511 |
| | 375,000 | 1,630 |
| | 400,000 | 1,899 |
| Buchanan | 275,000 | 1,009 |
| | 300,000 | 1,227 |
| | 340,000 | 1,665 |
| | 375,000 | 2,166 |
| San Carlos | 275,000 | 815 |
| | 350,000 | 1,351 |
| | 375,000 | 1,572 |
| | 400,000 | 1,831 |
| Palo Alto | 325,000 | 1,150 |
| | 375,000 | 1,573 |
| | 400,000 | 1,830 |
| | 425,000 | 2,117 |
| Reid-Hillview | 300,000 | 1,130 |
| | 325,000 | 1,478 |
| | 350,000 | 1,594 |
| | 400,000 | 2,233 |

Figure 6-10

DELAY CHARACTERISTICS -
PROPOSED PRIMARY AIRPORT EXPANSION
DEMAND AND PANCAP ( X 1,000)

## San Francisco Airport

| PANCAP = 562 | | PANCAP = 557 | | PANCAP = 492 | |
|---|---|---|---|---|---|
| Demand | Hours Delay | Demand | Hours Delay | Demand | Hours Delay |
| 475 | 5,260 | 475 | 5,532 | 450 | 6,531 |
| 500 | 6,486 | 500 | 6,854 | 475 | 8,606 |
| 550 | 10,918 | 550 | 11,710 | 492 | 10,679 |
| 562 | 12,655 | 557 | 12,693 | 500 | 11,739 |
| 575 | 15,041 | 575 | 16,254 | 525 | 15,778 |
| 600 | 20,866 | 600 | 22,838 | 550 | 21,541 |

## Oakland Airport

| PANCAP = 725 | | PANCAP = 695 | | PANCAP = 446 | |
|---|---|---|---|---|---|
| Demand | Hours Delay | Demand | Hours Delay | Demand | Hours Delay |
| 550 | 4,396 | 575 | 5,822 | 350 | 2,649 |
| 600 | 5,877 | 600 | 7,036 | 400 | 4,839 |
| 650 | 8,520 | 650 | 10,804 | 446 | 8,336 |
| 700 | 13,890 | 695 | 17,000 | 475 | 11,371 |
| 750 | 24,025 | 725 | 23,186 | 500 | 14,526 |
| 800 | 40,813 | 750 | 29,809 | 525 | 18,374 |

## San Jose Airport II

| PANCAP = 768 | | PANCAP = 309 | |
|---|---|---|---|
| Demand | Hours Delay | Demand | Hours Delay |
| 675 | 10,588 | 275 | 3,977 |
| 700 | 12,455 | 300 | 6,327 |
| 750 | 18,125 | 309 | 7,638 |
| 768 | 21,346 | 325 | 10,339 |
| 800 | 28,163 | 350 | 16,634 |
| 850 | 43,478 | 375 | 25,099 |

# 7. METHODOLOGY FOR A CONTINUING PLANNING PROCESS

************************************************************

## 7.1 - Evaluation of Alternatives

The BASAR study is being performed in two parts. This report is a portion of Part I - Collection and Analysis. The purpose is to analyze existing facilities and planned expansions to identify deficiencies between existing capability and demands. Part II is directed at the analysis of alternatives and the formulation of a comprehensive plan. The basis for the continuing planning process must be established at the end of Phase II.

It is suggested that the airport/airspace analyses results can be applied in a continuing planning process. The procedure involved would include defining the practical alternatives for airport expansion during Phase II, and then developing capacity/delay characteristics for each alternative. The capacity/delay characteristic appropriately stored (probably in an overall data storage computer program) could form the basis for later cost/benefit and other analyses.

To consider alternatives not previously evaluated could be accomplished by:

- Estimating the effect of minor changes.
- Using the Airport Capacity Handbook for analysis.
- Retaining consultant assistance for a specific, in depth analysis, or for a periodic update.

## 7.2 - Updating Data Bank

Another aspect of the planning process is the need for continual or periodic updating of the data bank. It is doubted if any attempt should be made to catalog the airspace picture other than as it is included in the airport capacity analysis. This is because the airspace/airway system can and is quite readily changed. As area navigation techniques come into operation in the next few years, airspace layout will be subject to even greater flexibility. It should be noted, however, that such changes are unlikely to have any major effect on the inter-airport conflicts analyzed and included in the capacity computations.

The data to be updated for airport capacity should be consistent with the method used to store capacity/delay characteristics - for example, the suggestion made above. If that is the technique used, then it would seem in order to store the data

needed to check the validity of the capacity/delay data. Criteria would be established to indicate when a data change was of sufficient magnitude to require a recomputation of capacity/delay.

The key data items to record and evaluate include:

1. Major changes in airport runway configuration or surfacing.

2. Changes in aircraft population.

3. Changes in hourly demand levels.

4. Changes in daily demand levels.

5. Changes in touch-and-go percentages.

6. Addition of IFR capability and airport lighting.

7. Evaluation of changes at nearby airports to see if any effect in airspace use.

8. Addition of control tower.

Data on Items 1, 6, 7 and 8, would have to be collected from the airport owners. Items 2, 3, and 5 are not recorded today except on special observation. Therefore some procedure would have to be established, probably a periodic data taking cycle, twice a year to gather new data. Item 4 is available from current FAA control tower records at airports with towers. Since all busy civil airports have towers, this is probably adequate since good estimates can be prepared for the lightly loaded airports. If needed, automatic counters (to count landings and takeoffs) have been devised and applied.

Thus, it appears there is reasonable possibility of including the capacity/delay characteristics and supporting data in a continuing planning process.

## ACKNOWLEDGEMENTS

********************

| | | |
|---|---|---|
| FAA Area Office Burlingame | - H.E. Aldrich | Area Manager |
| | Frank Happy | Chief, Air Traffic Branch |
| | Carl G. Hand | Chief, Airports Branch |
| | Frank Coil | Terminal Project Officer |
| | John L. Hopkins | Airport Planner |
| | J.B. Brunskill | Civil Engineer |
| Airports Managers/Operations | - James Brians | Livermore Manager |
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| ABAG Representative | - Paul Spiegel | |
| U.S. Navy | - Commander Baines Allen | |

# APPENDIX A

## THE COMPUTATION OF PRACTICAL HOURLY CAPACITY (PHOCAP)

*********************************************************

The computation of PHOCAP utilizes techniques which have been developed over a period of years. The original work was performed for the FAA beginning in 1959 and has been improved and updated to keep it current with aeronautical developments since that time. The original work was published in reports references 1, 2 and 3, and then updated in 1968 by the report reference 4 and 5. The methodology which resulted from the 1968 update included a capacity forecast for the effect of Computer Aided Approach Sequencing (sometimes known as metering and spacing system).

The above work was accomplished by the AIL Division of Cutler-Hammer. In 1969 the AIL group involved was acquired by R. Dixon Speas Associates and have since continued work in this area. At the present time the capacity computation technique is again being updated to include in it the effects of increased separation criteria required by the FAA when the 747 became operational.

The PHOCAP computation technique involves mathematical models which are based on queuing theory. Two basic queuing theory formulas are used as follows:

1. The First-Come-First-Served (FIM) model is used to compute the relationship between, 1) arrival rate and operating delay, and 2) the relation between departure rate and departure delay on a runway used for takeoffs only. This model has also been applied to compute operating rates and delay for the application of metering and spacing systems.

2. A specially developed queuing model for mixed operation on a runway - where both landings and takeoffs are operating. The model gives landings priority and then sequences departures into the gaps in the landing stream. The delay to departures is computed by this special model called Spaced Arrivals Model (SAM). The delay to arrivals is computed by the FIM model described above.

These mathematical models have been incorporated into a computer program which has the capability of adapting these models to the analysis of any common runway configuration. The total PHOCAP model will account for the following variables in airport design and operation:

1. Runway variations in length, turn-offs, turn-ons, and configurations.

2. Aircraft operational variables which are classified into five types (or more) of aircraft.

3. Weather variables as to whether VFR or IFR.

4. The time period of the analysis:
   - current operations up to 1975
   - past 1975 when metering and spacing systems will be in use

5. Instrument approach path length variations.

6. Instrument departure path as to number of paths available and their lengths.

7. Operating rules in effect.

8. Arrival to departure ratio.

The above eight items are described as inputs to the PHOCAP computer program and the relationship between operating rates and delay is calculated. A typical output is shown in attached Figure A-1 as average delay in minutes against movements per hour. From the illustration, it is seen that the delay varies with the movement rate. Thus if it is desired to establish an hourly capacity for a runway system, it is necessary to establish a level of delay at which it will be assumed the runway operation is at capacity. From the many years of work in this area it has been concluded that for major airports, the PHOCAP is reached when the average delay is four minutes. For smaller general aviation airports an average delay of two minutes is used.

The selection of this average delay has been influenced by many factors. One important point is that with this apparently low average delay of four minutes, the delay to individual aircraft will still vary from 0-18 minutes over a period of time. Since delay costs money, it is important that it not be allowed to go too high before action is taken to relieve the "lack of capacity"

situation. Further, the number of aircraft waiting in a queue (whether they are on the ground or in the air) is important to airport and air traffic operation, and the four minute delay level keeps the queuing to a reasonable level; at this level of delay, it is highly probable that over a peak period such as two hours, there will be times of no delay, and this means the queue is not carried over into adjacent hours.

Because PHOCAP is selected at a specific delay level it should be noted that the actual movement rate can exceed this number but with a higher delay level. That the model computes delay correctly has been determined by validating it against actual current operations. Of course the PHOCAP will change for a given airport if any of the eight inputs are changed as the model is sensitive to all of these input parameters.

# REFERENCES

***************


1. "Airport Runway and Taxiway Design", M.A. Warskow et al., AIL Report 7601-1, prepared under FAA Contract FAA/BRD-136, July 1960.

2. "Operational Evaluation of Airport Runway Design and Capacity", E.N. Hooton et al., AIL Report 7601-6, prepared under FAA Contract FAA/BRD-136, January 1963.

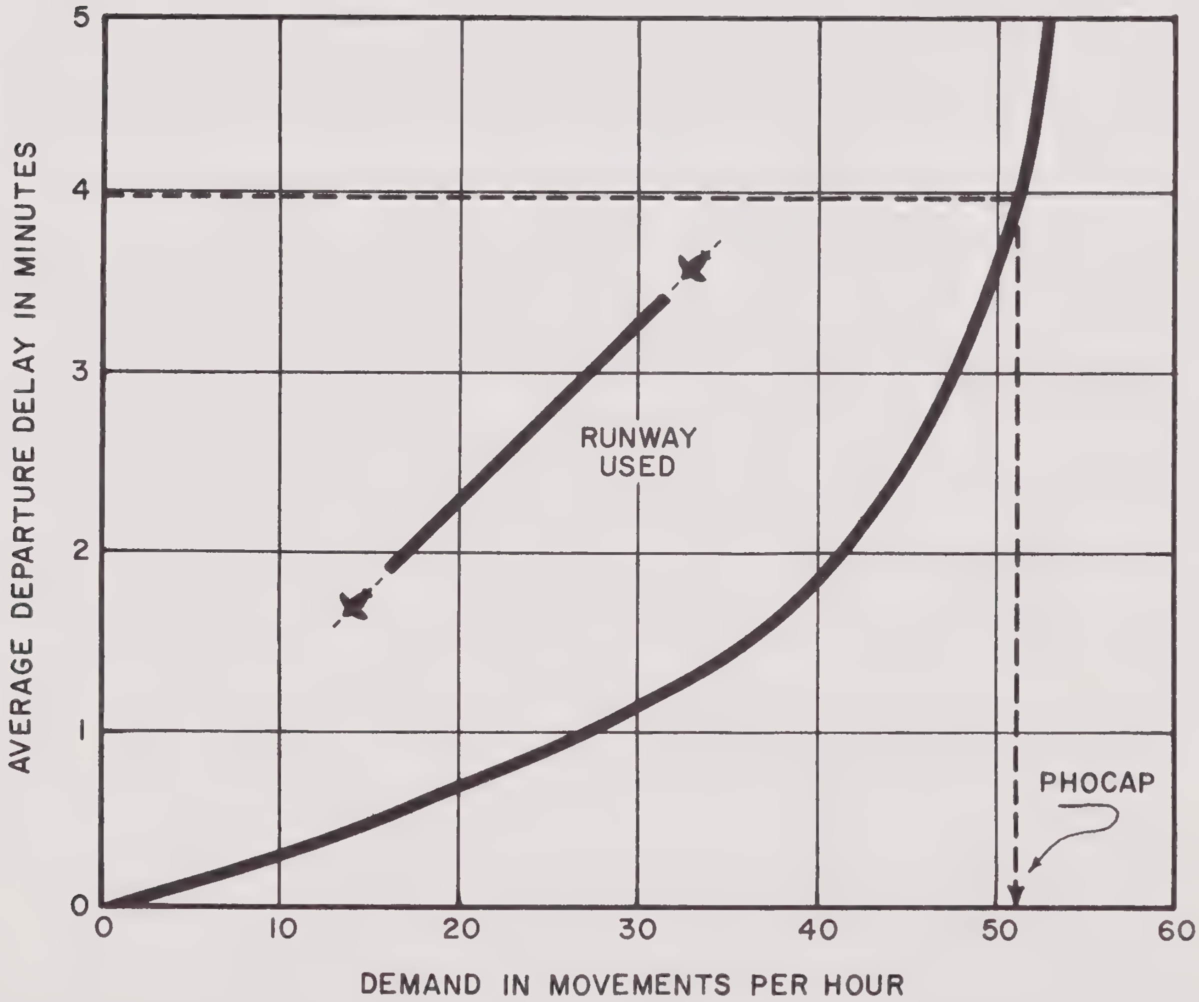
3. "Airport Capacity", Handbook prepared under FAA Contract FAA/BRD-136, June, 1963.

4. "Operational Development of Techniques for Computing Airport Capacity", E.N. Hooton, H. Burns, and M.A. Warskow, AIL Report 1167-1, prepared under FAA Contract FAA66WA-1521, June 1969.

5. "Airport Capacity Handbook, Second Edition", AIL Report 1167-H-1, prepared under contract FAA66WA-1521, June 1969.

FIGURE A-1

# TYPICAL PHOCAP ANALYSIS



# APPENDIX B

## COMPUTATION OF PRACTICAL ANNUAL CAPACITY (PANCAP)

*****************************************************

After a successful computation technique for hourly capacity had been developed (as indicated in Appendix A) and applied to actual airport analyses, it became evident that an additional capacity measure should be provided which would allow examination of airport capacity over a longer period of time. For example, at an airport which consists of two intersecting runways, it is probable that there will be six or eight hourly capacities that can be used resulting from operating the airport in the various different runway configurations. Which of these capacities should be used to compare airport capacity to airport demand? Further, as the capability to evaluate capacity developed, and it began to be applied to systems of airports, it was evident that a broader and more comprehensive capacity measure was needed. For example, two airports located in close proximity may operate independently and without conflict for 95% of the year but for the remaining 5% of the year they may seriously conflict and therefore reduce the total capacity. How should one evaluate this conflict if a single hourly capacity number is chosen to represent the situation?

From this experience in actual airport analysis, it became apparent that an annual capacity would be a very useful measurement to have for airport planning. The technique of annual capacity computation was developed and tested as indicated in References 1 and 2.

It has since been incorporated into a computer program and used in some 50 airport analyses as a useful planning tool. As with PHOCAP, the PANCAP computation is based on evaluation of delays. Annual capacity is selected at a predetermined delay level which assures a reasonable quality of operation to the airport user.

The PANCAP computation can be described by reference to Figure B-1. The hourly demand for an entire year is examined against the hourly capacity that is available. This is accomplished by describing the demand in terms of a typical hourly distribution of demand over a 24 hour period and then describing the way this typical hourly demand might vary for each day of the year. The year is grouped into 9 levels of VFR demand and 9 levels of IFR demand. Likewise, a thorough capacity analysis is performed resulting in a tabulation of the hourly capacity of the airport for both IFR and VFR into the PHOCAP and its percent of use during the year.

With both hourly demand and hourly capacity described for the year, the airport operation is then simulated for a whole year. In doing this, the delay is evaluated for every hour. If the demand is such that the PHOCAP value is exceeded, then that hour is recorded and the delay and the operations occurring during that hour are computed. The number of hours thus overloaded along with the delay and number of operations involved, are all tabulated and when they reach a given level this is considered to be the annual capacity. The levels of delay and overloaded hours have been selected on a basis which should assure reasonable service to the community using the airport.

It should be noted that the PANCAP computation permits the operation of the airport at delays above four minutes. In fact, the criteria is based on evaluating the hours when the delay exceeds four minutes. By limiting to a predetermined level the number of hours thus occurring, and the build up of delay in those hours, to a certain amount, a quality value is kept on the airport operation.

Because the annual capacity is based on an evaluation of these various factors, it is apparent that one can exceed the value selected as annual capacity, but at a higher price of delay and overloaded hours.

Since the PANCAP computation is based on the hourly capacity computation, it includes provision for all of the variables indicated in the discussion under PHOCAP. In addition, it incorporates all runway configurations used in both IFR and VFR operations and weather conditions throughout the year. For example, for the computation of PANCAP for a specific airport, all of the runway configurations which can be used will be determined in relation to wind directions and ceiling and visibility conditions. At a multi-runway airport, this may include variations in runway combinations from parallel runways, simultaneously in use, to single runways.

Since a whole year of operation is included, it is possible to incorporate into the PANCAP any conflict with another airport which results in a reduction in capacity to the airport.

For example, if during 5% of the year the approach situation at two adjacent airports is such that approach to one airport delays approach to another airport, this specific capacity situation is evaluated for 5% of the year at each airport and thus changes the delay situation and so affects PANCAP.

As previously mentioned for a multi-runway airport, there are usually several hourly capacities depending on which combination of runways is in use. The PANCAP computation permits evaluating all of these configurations and arriving at one annual number which represents annual capacity. The annual capacity can, in turn, be related to an average peak hour demand for 26 peak days of the year. This peak hour demand is recommended for planning purposes against such design items as gate facilities and parking requirements.

The PANCAP model and computer program have been applied to some forty airports of all sizes, many with several development approaches.

# REFERENCES

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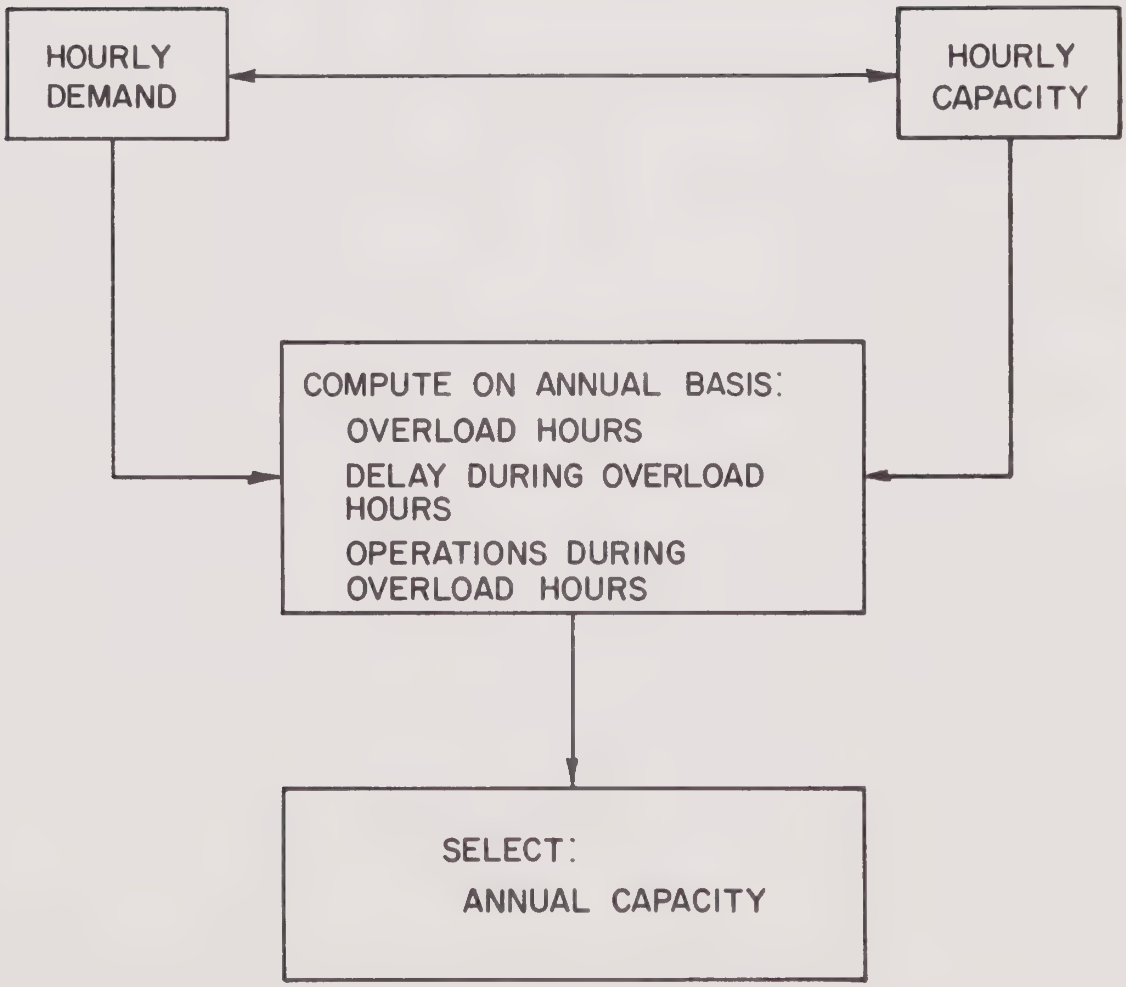
1. "Capacity of Airport Systems in Metropolitan Areas, Methodology of Analysis," M.A. Warskow et al., AIL Report 1400-4, prepared under FAA Contract FAA/BRD-403, January 1964.

2. "Capacity of Airport Systems in Metropolitan Areas, Validation," M. A. Warskow et al., AIL Report 1400-5, prepared under Contract FAA/BRD-403, January 1964.

FIGURE B-1

# SCHEMATIC OF PANCAP COMPUTATION



# APPENDIX C

## THE COMPUTATION OF ANNUAL DELAY (ANDE)

*******************************************

The PANCAP computation technique (Appendix B) has stressed that it is based on the evaluation of the delay to operations. Extension of this technique gives the capability of examining the delay to operations for an airport for a whole year. A computer program has been prepared which is very similar in format to that of the PANCAP computation to develop annual delay for a whole year.

This program, in effect, simulates annual airport operation as in the PANCAP program by comparing demand for each hour of the year to the capacity available for that hour, and then determining the delay that occurs in the hour. The delay for each hour is summed into a total annual delay for the year.

Arrival delay is computed separately from departure delay and then the two are summed for a total delay picture. However, they can be evaluated separately if desired, since arrival delay is generally considerably more expensive to the operator than is departure delay.

The annual delay calculation can be applied to any annual demand level that is desired, either below or above the PANCAP number. It is particularly useful in comparing a fixed demand for each of two comparable airport layouts, for it is a very useful cost/benefit analysis tool to measure the usefulness of two comparable airport plans. It also can be useful in developing a staging plan for construction of an airport, for it can be determined through cost/benefit analysis when it is worthwhile to add additional facilities and thereby reduce delay to operations. The PANCAP program has been applied to some 30 airports in numerous analyses and used for cost/benefit analysis purposes.

# APPENDIX D

## DESCRIPTION OF TRANSITION AIRSPACE MODEL (TRANSAIR)

*************************************************

This model has been developed to analyze enroute and/or transitional airspace. Its capability is such that it will encompass air route layouts which cover an area that could be 100 or more miles in each direction, and up to an altitude of 50,000 feet, depending on the complexity of the route structure. The model can be described as a steady state analysis of the complexity of control within the transitional area and enroute airway structure. The model is incorporated into a computer program and is described in terms of the inputs needed, the data stored within the program, and its output.

To operate the model, it is necessary to describe the air route structure to and from each airport within the area being analyzed. For each airport, the traffic on IFR flight plans is described in terms of the number of aircraft to and from each airport, the kinds of aircraft, and the routes used over the period of analysis (generally four hours). Within the air route structure, the route intersections are of special interest and are called "critical points".

Within the computer program is stored:

(a) The analytic model
(b) Aircraft performance for each type of aircraft such as the climb and descent characteristics, and preferred cruise altitudes.
(c) Tables which give a relative rating from an air traffic control standpoint for the interaction between aircraft based on the operating regime of the aircraft, such as climb versus climb, climb versus level, etc. The values in these tables are called "complexity rating". The values can be changed in scale to reflect the benefit of improved control equipment.

The computer program provides the following output:

(a) For each critical point the distribution of aircraft at that point with the altitude, airport going to/from and operating regime.
(b) For each critical point, the total complexity rating.

To use the model, the usual procedure includes a calibration run on the current traffic picture for the area being analyzed.

The current traffic picture is re-created by analyzing the records of enroute ATC, approach and departure ATC (flight progress strips) and possibly radar photography of the operation, to prepare the program input. Operation of the model then establishes the current situation which forms a basis for projecting into the future.

The model is then applied to the study cases. Through past use of the model, criteria have been developed for the level at which a critical point is overloaded. When this occurs, the air route system may be redesigned, if needed, to reduce critical point ratings to acceptable levels. The redesign of the airway system can be accomplished by either the addition of new routes, or the assumption of use of new control equipment (which then changes the complexity rating scale).

The model has been used in several studies of conventional and STOL type traffic as follows:

(a) New York - on a study to evaluate possible new airport sites, and on another study to evaluate the effect of air traffic control system improvements.
(b) Philadelphia
(c) Connecticut
(d) London
(e) The Oakland-San Francisco Bay Area
(f) Minneapolis

# APPENDIX E

## NOTES ON PUBLIC USE GENERAL AVIATION AIRPORTS

*************************************************

Information on the following airports, gathered during late 1969, is included:

1. Angwin

Operated by Frokes Aviation, Inc., this airport is located only one half mile outside the City of Angwin.

There are approximately 30 aircraft based on the airfield, which are used mostly for training, charter and instruction activities.

ANGWIN CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 101 | 70 |
| PANCAP | 126,000 | 88,000 |
| Demand | 20,000 | |

2. Antioch

Located two miles south of the city of Antioch, this airport has 53 based aircraft, most of which are single engines. There are also two gliders based here. The predominance of single engine aircraft is due to a charter and instruction school at the airport. Some aerial photography is also done out of this facility. Just to the north of the runway there is a sky-diving area.

ANTIOCH CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 184,000 | 130,000 |
| Demand | 30,000 | |

3. Buchanan Airport

Buchanan Airport is located just south of Suisun Bay and the Sacramento River Channel. It is very near the cities of

Pittsburgh, Antioch and Martinez, all three cities being the site of numerous major industrial offices and plants. It is easily accessible to the cities of San Francisco and Oakland by major highways and freeways (about 33 and 30 miles respectively). Student instruction, training, pleasure flying, corporate operations, plus air carrier and commuter schedules occupy the airport. San Francisco Helicopter operates six flights per day, and Golden Pacific Commuter Airline, six flights per day. Corporate operations include some small business jet aircraft.

Five flight schools and numerous flying clubs contribute substantially to the flight operations at the airport. Based aircraft have increased greatly in the past four years, in the amount of about 70 percent. This again, appears to reflect the population growth that has taken place. This airport should have good prospects for additional corporation and business type flying.

The nearest general aviation airport is the Antioch Airport, 14 miles to the east. The City of Concord to the east and the town of Pleasant Hill to the south are noise sensitive areas. Traffic patterns to the west of the airport are used as much as possible for noise abatement.

Terrain to the east, south and west have no appreciable effect on VFR operations, but does have an adverse effect on VOR instrument approach landing minimums.

Expansion to the present airport is restricted by the following land features:

- Main highways on the south and west.
- Walnut Creek Water Channel (350 feet wide) to the north and east.

National Airport Plan recommends land for clear zones, apron extension, install (and/or extend) HIRL, MITL, fire and rescue building, miscellaneous.

BUCHANAN AIRPORT CAPACITY SUMMARY

| | |
|---|---|
| Runways: | Two sets of parallel runways with centerline spacing of 500 feet. Runways are paved. Largest runway is 19R-1L, 5,000 feet and lighted. |

Wind Coverage: 99 percent-plus

IFR Capability: One type approach, a VOR approach from the Concord VOR facility. Approach clearances are delivered through Travis approach control. Landing minimums vary from 657 feet to 947 above ground and 1 to 2 miles visibility depending on category of aircraft and whether control zone is in effect or not. A departure SID is also published for instrument departures.

Population: D+E = 93%
C = 7%

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 167 | 110 |
| PANCAP* | 324,000 | 213,376 |
| Demand | 342,000 | |

* With improved instrument landing capability, the PANCAP will increase to approximately 340,000.

## 4. Calistoga Airpark

This airport is located within the city limits of Calistoga, with State Highway 29 to the east and the S.P. Railroad to the south and west. Due to the proximity of the City, procedures require takeoffs to the southeast and landings to the northwest, which limits airport capacity severely. Expansion of the airport requires relocating the runway to eliminate the above procedural requirements. The capacity shown below is that which will be available with the relocated runway. There is a skydiving area maintained to the north which is utilized every Saturday and Sunday. There is also moderate glider activity at the airport. Based aircraft include both powered aircraft and gliders.

CALISTOGA AIRPARK CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 168,000 | 104,000 |
| Demand | 10,000 | |

5. Cloverdale Municipal

This airport is enclosed on both sides by railroad tracks and rivers. Expansion onto more land is impossible. It is three miles south of Cloverdale and nine miles north of Healdsburg Municipal. This airport offers many services - charter, patrol, instruction, advertising and survey. All of the based aircraft (11) are single engine.

CLOVERDALE MUNICIPAL CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 222,000 | 137,000 |
| Demand | 12,000 | |

6. Fremont

The airport is located west of the Nimitz Freeway(State Highway 17), just outside of the San Jose City boundary. There are 45 based aircraft with almost all being single engine aircraft. The main activity of the airport includes chartering of aircraft and instruction, which accounts for the high percentage of single engine aircraft.

FREMONT CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 169,000 | 104,000 |
| Demand | 35,000 | |

7. Gnoss Field

Operated by the County of Marin, this airport is situated just off U.S.101 and north of the Novato Canal. It is about two miles north of the City of Novato. At present there are 99 based aircraft, of which 95 are single engine type. The two operators based at the airport are involved in charter and instruction activities.

The runway has been extended to 3,300 feet. Runway lights have been installed.

GNOSS FIELD CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 190,000 | 117,000 |
| Demand | 100,000 | |

8. Half Moon Bay

This airport is used as a weather alternate for San Francisco International Airport. It is also a provisional field for some air carriers. It is located only ten miles southwest of San Francisco International Airport, and six miles northwest of the town of Half Moon Bay.

Because of its functions as an alternate for San Francisco International, it handles aircraft ranging in size from DC-3's to the Boeing 727. However, the larger aircraft operate here only when the situation requires. As a population breakdown for capacity, a negligible amount of B's were allowed, seven percent C's, and the remainder D+E.

The majority of based aircraft here are single engine and are utilized for charter and instruction by the fixed base operation. Also, a VFR air taxi is run out of this airport.

HALF MOON BAY CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 112 | 78 |
| PANCAP | 184,000 | 128,000 |
| Demand | 108,000 | |

9. Hayward

Hayward Airport is located in an area that has shown considerable population growth. In spite of its better than average runway length, as compared to many general aviation airports, it does not seem to have attracted the larger twin or business jet trade as much as would be expected. The numbers of based aircraft also have not grown in relation to most of the other Bay Area airports. General aviation facilities at the nearby Oakland Airport have undoubtedly had a depressing effect on the use of Hayward by business and other visiting aircraft.

San Carlos and Sky Sailing lie at 12 and 13 miles distance respectively. Neither airport is in conflict with the Hayward patterns.

The main ILS approach for the Oakland International Airport lies over the west edge of the Hayward traffic pattern for runways 10R and 28L. The outer marker for the Oakland ILS runway 29 is located 4.6 nautical miles southeast of the approach end of Oakland's runway 29 and abeam of the Hayward Airport.

San Lorenzo Village is a critical noise area, located one-half mile off the departure end of runway 28L. For night takeoffs, it is suggested that runway 10R be used.

There are no plans at present for airport expansion due to land restrictions. The airport is bounded by a golf course on the northwest, highways to the northeast and southeast, and a newly developed industrial park on the southwest portion of the airport.

The National Airport Plan recommends taxiway construction, taxiway widening, apron and taxiway extension, runway and taxiway strengthening, install (and/or extend) MIRL, MITL, fire and rescue building, miscellaneous.

HAYWARD CAPACITY SUMMARY

| | |
|---|---|
| Runways: | Two parallel runways, 28L&R and 10R-7L, 5,971 feet and 3,300 feet respectively. 28L lighted. Both paved. |
| Wind Coverage: | 99 percent-plus |
| IFR Capability: | VOR approach using Oakland Omni station. Radar required for approach. Strobe and REIL lights are scheduled for installation at a later date. |
| Population: | 100 percent D+E |

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 192 | 101 |
| PANCAP | 363,000 | 191,000 |
| Demand | 283,912 | |

10. Healdsburg Municipal

Healdsburg Municipal is located about three to five miles northwest of Healdsburg and seven miles southeast of Cloverdale Airport.

The based aircraft consist mainly of single engine aircraft with several gliders.

Lytton Springs Road located 110 feet north of the runway is at the same elevation as the runway.

HEALDSBURG MUNICIPAL CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 222,000 | 137,000 |
| Demand | 15,000 | |

11. Livermore

This airport serves substantially as a reliever airport for other Bay Area general aviation airports. Much of the traffic generated here is from training flights from other congested areas, such as Palo Alto, Hayward, and San Carlos.

The airport is of additional importance in its role as a facility to serve the transportation needs of the A.E.C. and the Lawrence Radiation Laboratories located in the valley to the east. Very substantial operations are conducted by these organizations through contract flights with a private operator. These flights involve F-27 and some DC-3 aircraft.

Livermore is situated in a broad valley with low hills to the north, east and south. The airport is strictly a VFR airport, and terrain has no effect on the operations.

The nearest general aviation airport is Hayward Municipal, 15 miles west. There is no conflict between the traffic patterns of these two airports. The airport lies between two airways, V244 and V244s, but minimum IFR altitudes over these runways are high enough to eliminate any problem with Livermore traffic.

At present, there are proposed plans for a parallel runway to the south (length 3,200 feet). A city owned golf course lies at the west boundary of the airport. This land would be possibly

available for runway extension to the west. National Airport Plan recommends land for airport development and clear zones, taxiways and runway construction, apron extensions, fire and rescue building, miscellaneous.

LIVERMORE CAPACITY SUMMARY

Runways: One runway, 7-25, paved, lighted, 4,000 feet.

Wind Coverage: 96.6 percent

IFR Capability: No IFR Plate

| Population: | Current | Future |
|---|---|---|
| D+E = | 99% | 89% |
| C = | 1% | 11% |

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 132 | 88 |
| PANCAP | 236,000 | 157,000 |
| Demand | 269,620 | |
| Future: | | |
| PHOCAP | 168 | 116 |
| PANCAP | 301,000 | 208,000 |

12. Maine Prairie

This airport is located four miles south of Dixon, California, and about eight miles east of Nut Tree Airport.

There is an agricultural and instruction service located on the field. A restriction to traffic is that the traffic pattern cannot exceed 800 MSL.

MAINE PRAIRIE CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 4,000 | |

13. Morgan Hill

Morgan Hill Airport is a secondary airport located one mile north of Morgan Hill. The nearest airport is Reid-Hillview, 15 miles to the northwest.

The airport is located in between an orchard and a field. It has the room for expansion if it ever became necessary. There are approximately 35 based aircraft, 31 of which are single engine. The airport is not attended. It is a private strip and open to the public.

MORGAN HILL CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 190,000 | 117,000 |
| Demand | 20,000 | |

14. Napa County

Of all the general aviation airports in the Bay Area, Napa has the greatest potential for expansion and development into a major terminal. Takeoffs to the west and south are over water and/or open land and present no noise problem. There is ample space for runway extensions to the south and west.

This airport is currently served by Golden Pacific Airlines, a commuter airline, with five trips daily and three trips on the weekends. It is an extremely popular airport for fly-in operations because of an excellent restaurant in the terminal area.

The numbers of based aircraft have remained static for the past several years. Aircraft counts, however, have increased substantially due to the influx of training aircraft from the military and other congested general aviation airports in the Bay Area.

The nearest general aviation airport is the Sonoma Valley Airport, eight miles west. Hamilton Air Force Base lies 16 miles

to the southwest. There is no conflict between the VFR traffic patterns of these airports. Of some interest are the ADC scramble operations out of Hamilton. On a normal scramble mission, the interceptor jets takeoff in a southeasterly direction from Hamilton and make a left turn, low level-high speed, proceeding to the vicinity of the Napa Omni Station, from where they take their departure on their mission. This does not appear to pose any problem to VFR operations. Control during IFR weather would be exercised by Hamilton ATC.

The airport is located in a large area of flat country. There is high terrain to the north and east, the nearest high point being 2,280 feet at eight miles northeast. Terrain has no effect on VFR operations, but does require slightly higher circling minimums on the VOR instrument approach.

This airport has excellent capabilities for runway and other land use expansion. Future plans include extensions of the present runways to over 6,000 feet and the addition of two runways parallel to the present runways, length 3,000 feet each. There is a good potential for development of a hub type airport from the current configuration, with full IFR approach capabilities.

National Airport Plan recommends apron, taxiway and runway construction, apron extension, taxiway strengthening, MITL, fire and rescue building, miscellaneous.

NAPA COUNTY CAPACITY SUMMARY

| | |
|---|---|
| Runways: | Two runways, paved and lighted. Longest runway (18-36) 5,332 feet. |
| Wind Coverage: | 99 percent-plus |
| IFR Capability: | VOR approach with radar fix required. Approach clearance and radar advisory issued by Hamilton Approach Control. Landing minimums vary with operation of the control tower. |
| Population: | D+E = 95%<br>C = 5% |

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 133 | 101 |
| PANCAP | 258,000 | 197,000 |
| Demand | 189,541 | |

15. Nut Tree

Nut Tree is situated only two miles northeast of Vacaville and four miles southwest of Vaca-Dixon Airport.

The airport has one charter service based at the airport and the majority of based planes are single engine.

NUT TREE CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 190,000 | 117,000 |
| Demand | 37,000 | |

16. Palo Alto

Palo Alto Airport, like San Carlos Airport, is conviently located for general aviation flying. It is adjacent to high density population areas of the Peninsula. Growth in based aircraft has been about 60 percent in the past four years. Increasing traffic counts qualified the airport for a control tower, which was commissioned on 15 June 1969.

Nearest airports are - Moffett Field NAS, three miles southeast; Sky Sailing Airport at eight miles east-northeast; and San Carlos Airport at eight miles northwest. There are no conflicts with the Sky Sailing or San Carlos traffic patterns. Any significant departures from or extensions to the southeast of the Palo Alto traffic pattern can cause possible conflicts with the Moffett Field departure pattern. Large numbers of operational flights are conducted from this Navy facility.

There are no terrain problems affecting VFR operations at Palo Alto. Also, there are no immediate noise abatement problems. Takeoffs and landings are over marsh and tidelands and the traffic pattern is mostly over water.

Operations at the airport are dominated by student instruction, training and pleasure flying. San Francisco Helicopter

operates air carrier flights. There are two major flight schools and five small flying clubs based on the airport.

There are expansion possibilities to the present runway configuration. A parallel runway is proposed to be located to the northeast on the Bay side. Runway extensions are also possible to the northwest. A new parking area has just been completed on the southeastern area of the airport to accommodate more based aircraft.

Recommendations for Palo Alto Airport in the National Airport Plan are for apron, taxiway and runway construction, apron extension, fire and rescue building, miscellaneous.

PALO ALTO CAPACITY SUMMARY

| | |
|---|---|
| Runway: | One runway, paved, lighted. Length 2,500 feet. |
| Wind Coverage: | 99.25 percent |
| IFR Capability: | No IFR Plate |
| Population: | D+E = 100% |

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 130 | 84 |
| PANCAP | 239,000 | 154,000 |
| Demand | 191,000 | |
| Future: | | |
| PHOCAP | 204 | 120 |
| PANCAP | 375,000 | 220,000 |

17. Petaluma Sky Ranch

This secondary airport is located one mile northeast of Petaluma and nine miles southwest of the Sonoma Valley Airport.

There are 70 based aircraft of which most are single engine. Located on the field are charter, patrol and instruction services. Also an air taxi is run from the airport.

PETALUMA SKY RANCH CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 250,000 | 154,000 |
| Demand | 52,000 | |

18. Reid-Hillview

Reid-Hillview is classed as a reliever airport for San Jose Municipal. It is a typical sport type, general aviation airport. Population growth has been substantial in the area and with it, based aircraft have increased about 74 percent in the past four years.

Two major flight schools and 14 flying clubs operate out of this airport. The flying clubs operate approximately 64 aircraft.

The nearest airport is the San Jose Municipal Airport, located 4.5 miles northwest. The final approach (ILS) course lies about 2.5 miles to the west with the outer marker southwest and abeam of Reid-Hillview Airport. With the right-hand traffic pattern to the east of the airport, there is no conflict with inbound aircraft to the Municipal Airport.

In regard to noise abatement, housing to the north and west are sensitive areas. Traffic patterns to the east minimized noise to populated sections.

A parallel runway to the west of the present runway is now under construction. Runway extensions are very limited due to the housing development one-half mile to the north and a large shopping center in line with the runway to the south.

National Airport Plan recommends land for airport development, apron, taxiway and runway construction, fire and rescue building, miscellaneous.

REID-HILLVIEW CAPACITY SUMMARY

| | |
|---|---|
| Runways: | One runway, 31-13, lighted. Length 3,100 feet. |
| Wind Coverage: | 99.50 percent |
| IFR Capability: | No IFR Plate |
| Population: | D+E = 94%<br>C = 6% |

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 136 | 108 |
| PANCAP | 251,000 | 199,000 |
| Demand | 224,367 | |
| Future: | | |
| PHOCAP | 184 | 118 |
| PANCAP | 339,000 | 217,000 |

19. Rio Vista Municipal

This airport is located just west of the Sacramento River one mile north of the town of Rio Vista.

The hangars violate the 250 foot landing strip width and transitional surfaces.

An agricultural flight service is operated out of this airport.

RIO VISTA MUNICIPAL CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 250,000 | 154,000 |
| Demand | 11,000 | |

20. San Carlos

San Carlos Airport is located in a high density population area. It is conveniently situated for general aviation use and has shown substantial growth in activity over the past several years.

Student instruction, training and pleasure flying are the main activities of the airport. Four flight schools and six flying clubs contribute to the substantial training activities at this airport.

The nearest general aviation airport is the Palo Alto Airport, eight miles southeast. There is no conflict between the traffic patterns of the two airports. The main approach corridor (ILS and VFR) to the San Francisco International Airport lies 2.5 miles northeast of the San Carlos Airport. Air carrier aircraft passing abeam of San Carlos will normally be at an altitude of about 1,700 feet MSL. This provides vertical separation as the VFR traffic pattern is 700 feet at San Carlos.

There are no critical areas at present; however, a serious noise problem is in the making with the construction of the Redwood Shores Housing Development now in progress adjacent to the airport. The development is located north and east of the airport and there is little question but that the present traffic pattern will cause noise complaints from this area when completed.

The San Carlos Chamber of Commerce has initiated a proposal for adding a second runway. It would be 2,300 feet in length and parallel to the present runway. This addition, if accomplished, would pretty well exhaust the capabilities for further runway extensions or additions at this airport. Further expansion is limited by:

- Highway 101.
- Freeway to the west boundary.
- An access road to Redwood Shores to the north.
- A navigable water slough to the east.
- A storm drain outflow canal to the south.
- A Redwood Shores tract to the north and east, now under construction.

National Airport Plan recommends land for airport development and clear zones; apron and taxiway construction; apron taxiway and runway extension; install (and/or extend) MIRL, MITL, fire and rescue building, miscellaneous.

SAN CARLOS CAPACITY SUMMARY

Runways: One runway, 30-12, paved, lighted. Length 2,600 feet.

Wind Coverage: 99.25 percent

IFR Capability: No IFR Plate

Population: D+E = 100%

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 146 | 98 |
| PANCAP | 268,000 | 180,000 |
| Demand | 300,000 | |
| Future: | | |
| PHOCAP | 204 | 120 |
| PANCAP | 375,000 | 220,000 |

21. Santa Rosa Air Center

This airport is located three miles south-southwest of Santa Rosa and five miles south from Coddingtown Airport.

There is an instruction school based on the field and the majority of based aircraft are single engine.

SANTA ROSA AIR CENTER CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 190,000 | 117,000 |
| Demand | 24,000 | |

22. Santa Rosa Coddingtown

The airport is located only two miles outside the City of Santa Rosa and also only five miles southeast of Sonoma County Airport.

Among the many activities administered from the airport are - charter, instruction, agricultural, advertising, survey, sales, rentals, air ambulance, and helicopter services.

The majority of the based aircraft are single engine. The airport has an air taxi service and maintains a daily schedule utilizing Twin Otters in this operation.

SANTA ROSA CODDINGTOWN CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 250,000 | 154,000 |
| Demand | 70,000 | |

23. Sea Ranch

The Sea Ranch is situated four miles north of the City of Stewarts Point and eleven miles east-southeast of Ocean Ridge Airport.

There are no based aircraft at this airport.

SEA RANCH CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 168,000 | 104,000 |
| Demand | 2,000 | |

24. Sky Sailing

This is a small privately owned strip located to the northwest of Fremont Airport, just west of the Nimitz Freeway. The airport does not allow any touch-and-go operations. It is primarily a glider base operated year-round, seven days a week. There are 17 powered aircraft (all single engine) based here and approximately 50 gliders. A landing fee is charged.

SKY SAILING CAPACITY SUMMARY

| | Zero Touch-&-Go |
|---|---|
| PHOCAP | 75* |
| PANCAP | 93,000* |
| Demand | 70,000 |

* These figures are based on service times for powered aircraft.

25. Sonoma County

Sonoma County Airport is located in an area of strong population growth. There is a steady growth of small service type industries, electronic and computer companies. Lumber processing is also a predominant industry.

The future status of the two neighbor airports, Coddingtown and Air Center, is uncertain. They are both privately owned and quite vulnerable to the inroads of industrial and housing expansions that may occur. It is quite possible that Sonoma County Airport will become the sole airport to serve this area within the next decade. With the forecast growth in this area, it would appear that the county airport will grow in importance substantially over the next few years. It is a likely candidate for an ILS system to cope with fog type weather that produces

ceilings down to 100 or 200 feet. Increased air carrier and commuter schedules will create a demand for an approach system that will lessen weather interruptions.

Student instruction, training, pleasure flying, aerial fire fighting, business aircraft and air carrier schedules are the predominant traffic at the airport. There are two flight schools and one flying club. Golden Pacific Commuter Airlines operates seven flights per day during the week and four flights on weekends. Air West, a scheduled air carrier, operates four flights daily. There are no regular helicopter operations at this airport.

There are no critical noise problems. The airport management and City Council are active in rezoning for land use in the vicinity of the airport and have established height limitation zones in the area. Occasional noise complaints are received from south of the airport in connection with periods of heavier-than-normal jet and fire-fighter tanker traffic.

There are no immediate plans for extending the present runways. There is a proposal for adding a 3,000 foot parallel runway to the present runway 14-32, for use by training aircraft and touch-and-go operations. There are plans to strengthen existing taxiways and to add a general aviation taxi strip at the north end between the approach ends of runways 14 and 19. This will increase the use of runway 19.

The National Airport Plan recommends land for clear zones, taxiway widening, apron, taxiway and runway extension, runway and taxiway strengthening, install (and/or extend) MIRL, MITL, miscellaneous.

SONOMA COUNTY CAPACITY SUMMARY

| | |
|---|---|
| Runways: | Two runways, inverted "V", paved, length 5,000 feet and 14-32 lighted. |
| Wind Coverage: | 99 percent-plus |
| IFR Capability: | VOR approach to airport with facility located on the airport. Weather minimums for landing 400 feet-one mile straight in with control zone effective. A 75 MC fan marker is installed 5.6 nm from the airport on the VOR final approach course, used for altitude reduction on final to MDA. |
| Population: | D+E = 90%<br>C = 10% |

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 110 | 73 |
| PANCAP | 226,000 | 150,000 |
| Demand | 103,175 | |

26. Sonoma Sky Park

The Sky Park is located 2.5 miles south of the City of Sonoma and three miles north of Sonoma Valley Airport.

Among the services at this airport are a charter service and an instructional school.

SONOMA SKY PARK CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 10,000 | |

27. Sonoma Valley

Sonoma Valley Airport is situated five miles south of the City of Sonoma and 2.5 miles south of Sonoma Sky Park Airport.

A charter and instructional service is operated out of this airport.

SONOMA VALLEY CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 171,000 | 105,000 |
| Demand | 23,000 | |

28. Smith Ranch

This facility is located four miles north of San Rafael. Expansion of this airport would be very difficult at best. On each side of it are creeks (South Fork and Gallinos), and on the west end tracks of the NWP Railroad.

There are no fixed base operators on this airport and only 21 based aircraft. Smith Ranch is a private airport. It is not attended.

SMITH RANCH CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 190,000 | 117,000 |
| Demand | 15,000 | |

29. Tremont Airport

Located four miles south-southeast of Davis and six miles east-northeast of Dixon, this airport has four based aircraft (one of which is multi-engine). This airport has a single 2,000 foot oiled runway and one fixed base operator.

| | |
|---|---|
| PHOCAP | 122 |
| PANCAP | 152,000 |
| Demand | 10,000 |

30. Usibelli Restaurant

This airport, operated by the Usibelli Mine, Inc., is located two miles east from the City of Pope Valley.

There is very little demand on the airport, which accounts for the negligible amount of based aircraft and lack of fixed base operators.

Approach-departure surfaces to the northwest are violated by trees and Pole Lines.

USIBELLI RESTAURANT CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 168,000 | 104,000 |
| Demand | 3,000 | |

31. Vaca-Dixon

Freeway U.S. Highway 40 is located 400 feet from the end of runway 16 and 350 feet from the end of runway 18. An access road is located at the adjacent end of runway 36.

There is a predominance of single engine planes at the field and a charter service operates out of it.

VACA-DIXON CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 171,000 | 105,000 |
| Demand | 5,000 | |

32. Vacaville

Vacaville Airport is situated two miles southwest of Vacaville. It is also four miles southwest of the Nut Tree Airport.

There are no lights on the airport, but flares can be used by local pilots if a prior request is made. There is a charter and instruction service located on the field.

VACAVILLE CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 168,000 | 104,000 |
| Demand | 10,000 | |

# APPENDIX F

## NOTES ON PRIVATE GENERAL AVIATION AIRPORTS

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Information on the following airports, gathered in late 1969, is listed below:

1. Branscomb Emergency

This is a very small private strip (700 feet) located five miles south of Healdsburg. It is for personal use only and closed to the general public.

BRANSCOMB EMERGENCY CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 20,000 | |

2. Byron Airpark

The airport is located one mile south of Bryon, adjoining Byron Hot Springs Resort. This is a private airport and is not open to the public. Also, there are no based aircraft.

BYRON AIRPARK CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 171,000 | 105,000 |
| Demand | 2,000 | |

3. Delta Air Park

This airport's primary function is only that of an emergency landing field. The owner resides at the west end of the runway. Because of this, the airport can be considered attended around the clock.

This airport is a private airport due to the fact that it lacks county zoning for commercial. There is only one single engine aircraft based here.

DELTA AIR PARK CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 2,000 | |

4. Dickinson-Dorward

This is another single runway, private facility located in Marin County. It is approximately two miles southeast from the City of San Rafael. As most private airports, it is also unattended.

Based aircraft are very small in number at this airport. This private airstrip is open to the public only in case of emergency.

DICKINSON-DORWARD CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 121 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 3,000 | |

5. Discovery Bay (Riverlake)

This is also a small private, unpaved field, located 2.3 miles northeast of the City of Byron.

All approaches are right-hand because of high tension lines east of the field.

Based aircraft consist of only two single engine aircraft. This airport is listed as private and is closed to the public.

DISCOVERY BAY (RIVERLAKE) CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 3,000 | |

6. Flying "K"

This small private strip is located two miles north of the City of Windsor. This airport is not open to the public.

FLYING "K" CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 200,000 | 123,000 |
| Demand | 2,000 | |

7. Graywood Ranch

Graywood Ranch Airport is located eight miles east of the City of Santa Rosa. It is a small private airfield consisting of two runways.

GRAYWOOD RANCH CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 171,000 | 105,000 |
| Demand | 1,000 | |

8. Hinman Flying "H" Ranch

This small private strip is located near the City of Petaluma. It is closed to the public.

HINMAN FLYING "H" RANCH CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 2,000 | |

9. Hummingbird Haven

The facility is located in the midst of farm land and pastures. One detracting element of the site is a radiological laboratory located one mile southwest which requires a minimum altitude of 150 feet. The total based aircraft are three single engine planes and 16 gliders. The airport is designated as a glider-port and powered aircraft are not allowed (the hangar is marked "Glider Port, airplanes keep out, landing fee"). Touch-and-go figures are not applicable for their type of operation. This airport is not open to the public. The current annual demand is low and estimated at 2,525 movements.

10. Inglenook Ranch

Inglenook Ranch airfield is located 1.5 miles to the northwest of Rutherford. The airport is a private strip and is not open to the public. It can be used for emergency landings only by itinerant aircraft.

The only obstructions are a Pole Line to the southeast and a hill to the northwest.

INGLENOOK RANCH CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 168,000 | 104,000 |
| Demand | 2,000 | |

11. Mazza

This is another small (1,200 feet) private strip used only for personal use. It is located four miles southeast of Petaluma.

MAZZA CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 152,000 | 93,000 |
| Demand | 3,000 | |

12. Meadowlark Field

Meadowlark Field is located 3.5 miles east, southeast of Livermore. It is a single runway facility that is unattended. There are four single engine aircraft based here, and there are no fixed base operations. This airport is not open to the public.

MEADOWLARK FIELD CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 135 | 83 |
| PANCAP | 168,000 | 104,000 |
| Demand | 1,000 | |

13. Moskowite

This airport is located in a unique vicinity. It is 11 miles north-northeast from Napa and enclosed by mountains on three sides. Landings and takeoffs are restricted. Landings are made in one direction, and takeoffs are made in the opposite direction. This is a severe restriction on capacity.

Because of its location, touch-and-go figures were not developed.

It is a private strip and open to the public only for emergency use.

MOSKOWITE CAPACITY SUMMARY

| | |
|---|---|
| PHOCAP | 52 |
| PANCAP | 65,000 |
| Demand | 2,000 |

14. Travis AFB Aero Club

This air field is approximately three miles east of the City of Fairfield. The airport is not open to the general public. It is a military aero club.

TRAVIS AFB AERO CLUB CAPACITY SUMMARY

| | Average Touch-&-Go | Zero Touch-&-Go |
|---|---|---|
| PHOCAP | 122 | 75 |
| PANCAP | 200,000 | 123,000 |
| Demand | 2,000 | |